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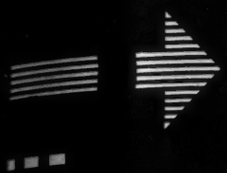

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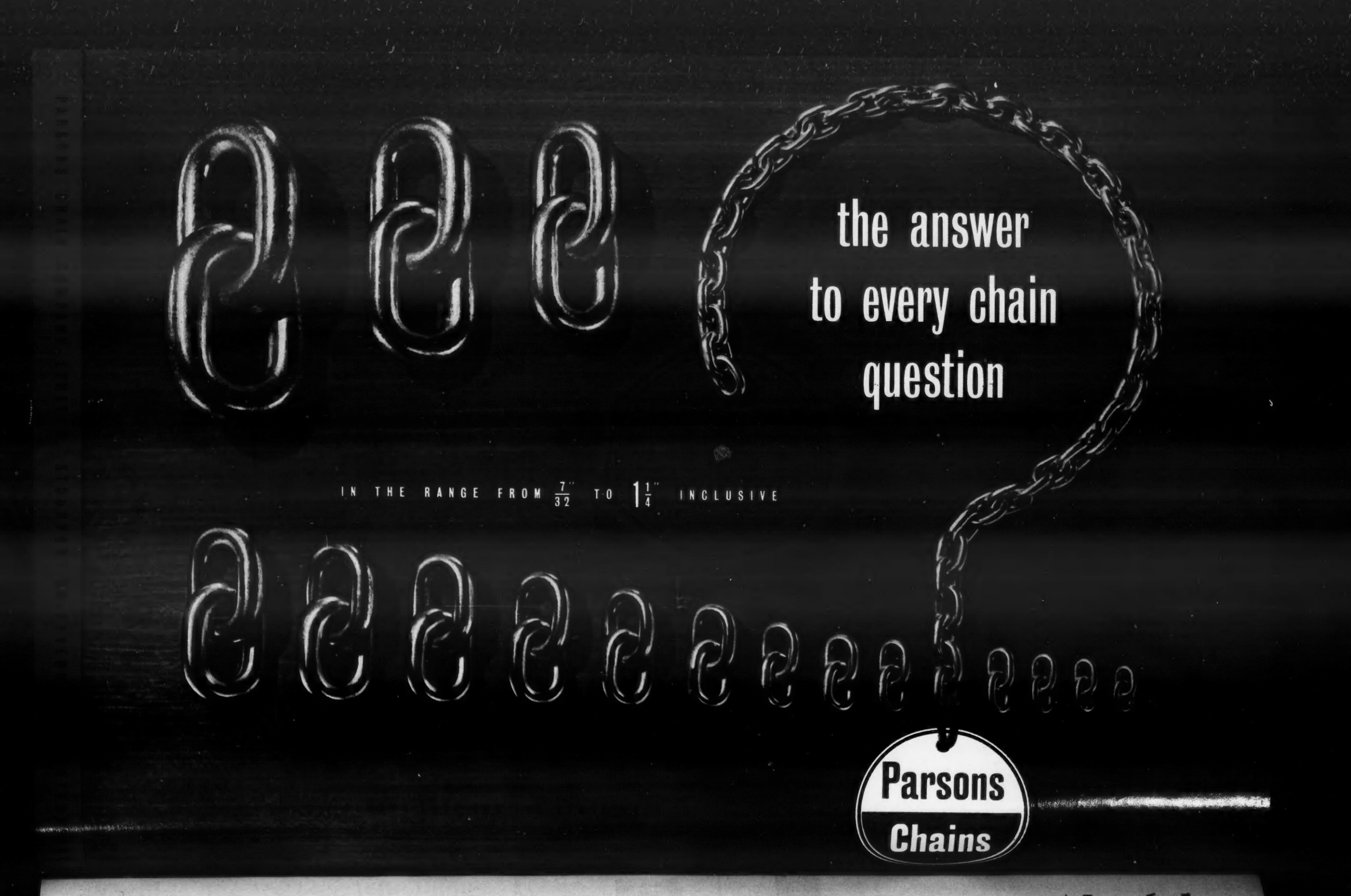
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Cover Picture

Standard test for determining the load factor of compression springs. (*Nurnberg photograph for* ENGINEERING)

We have been informed that the cover picture of the issue of 24 February was not of the 3,000 hp electrical drive for a steel mill, as stated, but of the twin drive, of 8,000 hp (total), of a hot reversing mill for the production of aluminium.

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(including full board)

Forms of enrolment and copies of the syllabus may be obtained from THE WARDEN, THE COLLEGE OF AERONAUTICS, CRANFIELD, BLETCHLEY, BUCKS. F 75

IMPERIAL COLLEGE: BURSARIES in HIGHWAY ENGINEERING provided by the Rees Jeffreys Road Fund, tenable from October, 1961. Value from £460 to £760 per annum including fees. Further particulars from the REGISTRAR, IMPERIAL COLLEGE, LONDON, S.W.7. Closing date, APRIL 15th, 1961. F 57A

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37TH (1961) EXAMINATION

Application forms for entrance to the 1961 Examination, which should be returned not later than the 1st JUNE, 1961 (the 1st July for those taking Part 3 (The Design Problem) only), may be obtained from the GENERAL SECRETARY, THE INSTITUTION OF CHEMICAL ENGINEERS, 16 BELGRAVE SQUARE, LONDON, S.W.1. F 60

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Further details and forms of application for admission may be obtained from the SECRETARY, CAMBRIDGE UNIVERSITY DEPARTMENT OF ENGINEERING, TRUMPINGTON STREET, CAMBRIDGE. F 70

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AERODYNAMIC PRINCIPLES OF THE HELICOPTER

will be given at the College from MONDAY, 1st MAY, to FRIDAY, 5th MAY, 1961

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A copy of the syllabus and forms of enrolment may be obtained from THE WARDEN, THE COLLEGE OF AERONAUTICS, CRANFIELD, BLETCHLEY, BUCKS. F 71

ENGINEERING Impact

of the High Demand for New Machinery

THE substantial orders by the British centred oil firms in 1960 for equipment made in the United Kingdom —the value was almost £119 million— underlined the part the capital goods section of the engineering industries has been playing in the overall level of manufacturing activity. About 56 per cent of the new equipment is to be used at overseas installations.

The same emphasis on capital goods was seen in the January trade returns, where the improvement in exports was brought about by better sales of machinery and manufactured metal goods. Exports from the United Kingdom rose fastest to Western Europe and Latin America, where they increased by 6 per cent.

The lively activity in modernising and re-equipping manufacturing industries is a two-way business. British machinery imports were also increasing, with the United States and Canada providing most of the imports.

Looking a little further back, over the four months to October, total engineering exports were held down to only 1 per cent increase by the slump in UK overseas car sales. Machinery and commercial vehicles exports in the same four months were up by 10 per cent.

An example of the work British companies are doing for the United States market is provided by the Bronx Engineering Company, of Stourbridge, Worcestershire. A Louisiana firm has ordered a large set of Pinch-Pyramid plate bending rolls, weighing 120 tons and able to cold-roll mild steel plate 12 ft wide by 3¼ in thick or of pre-bending mild steel plate 12 ft by 2 in at a speed of 18 ft a minute. This is believed to be the first order with a British firm for this type of equipment for United States industry.

A Straight Decision on the new Cunarder

Before the end of the month the Cunard company are expected to have invited tenders for their new Atlantic express liner. Tied up in the struggle for the order, the outstanding industrial prize in the year, or of any year for the shipbuilders, are questions of prestige, of experience to be gained in no other way, and of continued employment for the successful yard.

In four areas—at Belfast; on the Clyde, where the name John Brown at once brings to mind the name of the liner to be replaced, but where the highly modernised Fairfield Engineering once built famous Atlantic Riband winners; on the North East coast where a powerful consortium has been set up with this job in view; and at Birkenhead —there exists the conviction that the local yard could do the best job and the certain knowledge that if the contract is brought home shipyard employment there will be given a certainty of which there is no other prospect.

The opinion is frequently met that the award of the contract to a particular yard will be influenced by this consideration of unemployment. Against that there is the statement from Mr. Marples, the Minister of Transport, that the shipyard "which submits the best proposition will receive the tender."

Overseas this may not remove the feeling that the decision is swayed by social factors. After all, the Government has enforced decentralisation on the motor industry's expansion plans, a path not entirely defensible on the grounds of the lowest cost for the best possible product.

In the case of the new Queen liner, however, one of the best arguments in favour of building the ship at all (when the number of passengers crossing the Atlantic by air rather than by sea ascends constantly) is its plain and unmistakable demonstration of the capacities of British ship designers and shipbuilders.

The volume of employment created by the project will be much the same wherever the building is undertaken. And it so happens that the work looks like being equally badly needed in at least three of the four areas concerned.

If the maximum advantage to the shipbuilding industry is not to be dissipated, it is important that it should be clearly seen that the best proposition, and that alone, is the criterion for selecting the shipyard to do the job.

For this reason full publicity should be given to the rival bids and to the reasons for the final decision.

Opposing the Road Tax Imposition

With the German economy enjoying a degree of success which makes possible an increase in the value of the Deutschmark, no serious proposal for making Britain similarly successful in her overseas trade can be ignored.

Inevitably a stream of ideas, some for putting greater steam into the United Kingdom's production, others for redistributing the tax burden, flow into the Treasury in this pre-budget season.

From the British Road Federation has gone a proposal urging the reduction of road user taxation by 30 per cent. This falls into both categories. Cutting the costs of road transport, which presumably lowering the taxes would do, might well make for greater price competitiveness on the export markets by reducing manufacturing costs all round. Since the British Road Federation make no suggestions for cutting down Government expenditure, it brings their request within the ambit of suggestions for redistributing the tax load.

Speaking for more than 250,000 commercial vehicle operating firms, the British Road Federation complains that while road user taxes were less than £300 million in 1951 (the year that petrol tax was increased to 2*s* 6*d* a gallon) by this year it is estimated the road user taxes will collect £657 million.

The BRF have dug out a Government report of 30 years ago which says: "we consider that the total contribution payable by all classes of mechanically propelled vehicles . . . should be equal to the current expenditure on the roads without net addition or reduction . . ."

This is a timely reminder to the Government when spending on roads is only a fifth of the lucrative income from road taxes.

Another witness the BRF usefully put before the Government is the newly appointed Economic Adviser, Professor Cairncross. In the *Westminster Bank Review*, of February, 1955, he wrote: "Industrial efficiency in this country turns just as much on cheap and convenient transport facilities, and on adequate supplies of low cost fuel and power, as on high productivity within factories . . . the state of the roads introduces an eloquent question mark."

of Gathering Speed in Nigerian Development

Of a total of 21 projects for United Kingdom investment in Nigeria, seven have been firmly decided upon since the return to Britain of the Federation of British Industries' recent mission.

The industrialist investing in Nigeria has the benefit of a "pioneer certificate" by which he is given relief from company tax for four years. Nigeria is following the pattern of other developing areas of the world who seek to attract new industries by granting an accelerated depreciation allowance, in addition there are possibilities of tariff protection and relief from duty on imported raw materials.

Among the projects in which British interests are concerned are the United Africa Company's scheme for a £2½ million textile plant in Eastern Nigeria, the Dunlop plan for a £2 million tyre factory and the proposal from Arthur Guinness to build a £1 million brewery.

Other plans are for the production of commercial vehicles, paints, cables and metal containers and batteries.

The Federation of British Industries' advice was not all of the go-right-ahead variety. The Nigerian Government is interested in its own steel industry using local ores. The FBI mission's view was that the opportunity does not exist at present to undertake this development. It did suggest that there is scope for setting up mills for the processing of local scrap and imported billets. While a processing mill might cost £300,000 the capital required for a full-scale Nigerian steel industry would possibly be in excess of £12 million.

Further recommendations for the development of Nigeria, which would lead to more world trade including the import of capital equipment were: expansion of brewing and textile manufacture, the setting up of cocoa processing plants, greater vehicle assembly and a start on local production of components and the beginning of softwood plantations for paper making.

The Market over the Water

Western Europe uses up chemicals at five times the rate of Great Britain, and is accelerating its consumption at twice the pace of this country.

This alone makes Europe a prospect altogether too promising to be ignored by the British chemicals industry. But in addition the tariff changes in the European Common Market under the Treaty of Rome will move steadily against exports of chemicals from the United Kingdom, and there is no sign of any certain change in this trend.

Against this background Imperial Chemical Industries have taken the decision to establish, on the scale of the Wilton, North Yorkshire, chemicals "town," or of the Severnside development, a £100 million series of installations on a 300 acre site near Rotterdam, in the Netherlands.

It is anticipated that the Rotterdam plant will produce the polyethylene and polypropylene plastics and ethylene and may also manufacture Terylene, ethylene glycol and ethylene oxide. This may be expected to be the first of a number of ICI enterprises in the Common Market.

The company has stated that there will be no let-up in the efforts to sell increasing quantities of chemicals from the United Kingdom to Europe but the move is certainly recognition, by one more major British company, of the reality of the trading significance of the large, prosperous, and fast expanding market within the increasingly preferential tariff wall of the European "Six."

With a Wilton-sized ICI installation in the Common Market, in addition to the European investments of a large part of the United States chemicals industry, the chances are that in time there must come about a new emphasis in the direction of British chemical exports. So far the Commonwealth, which takes chemicals from the United Kingdom to a value not so far behind the rest of the world put together, buys mostly heavy chemicals and fertilisers. But heavy chemical manufacture is being increasingly opened up around the world, giving a briskly taken opportunity for the sale of plant and know-how while cutting sharply into the future prospects in these categories.

At the same time the use of natural gas from the Sahara and Italy by the European chemical manufacturers will give them important cost advantages.

The result may well be to turn the chemical industries towards more and more sophisticated products.

In this connection it is worth observing that ICI are to build new research laboratories at Runcorn Heath, Cheshire. The laboratories are for the general chemicals division whose expansion in the past few years has been most pronounced in chlorinated solvents, monomers for synthetic fibres and plastics, and in organic fluorine products.

and the Need for Industrial Hygienists

A very broadly based group of speakers has been assembled for a London conference next month on the need for "hygienists within industry in the United Kingdom."

Chief medical officers from the National Coal Board, Imperial Chemical Industries and Esso Petroleum will be speaking, in addition to Mr. H. F. Spencer, managing director of the steel company, Richard Thomas and Baldwins, and Dr. G. J. Fortuin of the Philips Company, of Eindhoven.

Following the morning session devoted to discussing the occupational hygienist and industry, papers will be heard in the afternoon on the facilities for training available in a number of industrial health departments of universities.

Pioneering work in industrial medicine has been done at Slough, Buckinghamshire, and Dr. D. E. Hickish, industrial hygiene engineer of the Slough Industrial Health Service, is among the speakers.

Making Good Use of Blast Furnace Slag

Blast furnace slag is being crushed and graded to a first-rate aggregate. There is growing recognition of the fact that this "by-product" is not a second-best.

A SLAG processing plant has been built alongside Steel Company of Wales's works at Port Talbot. It replaces a smaller slag processing plant for black-tops previously operated by Wimpey on a nearby site.

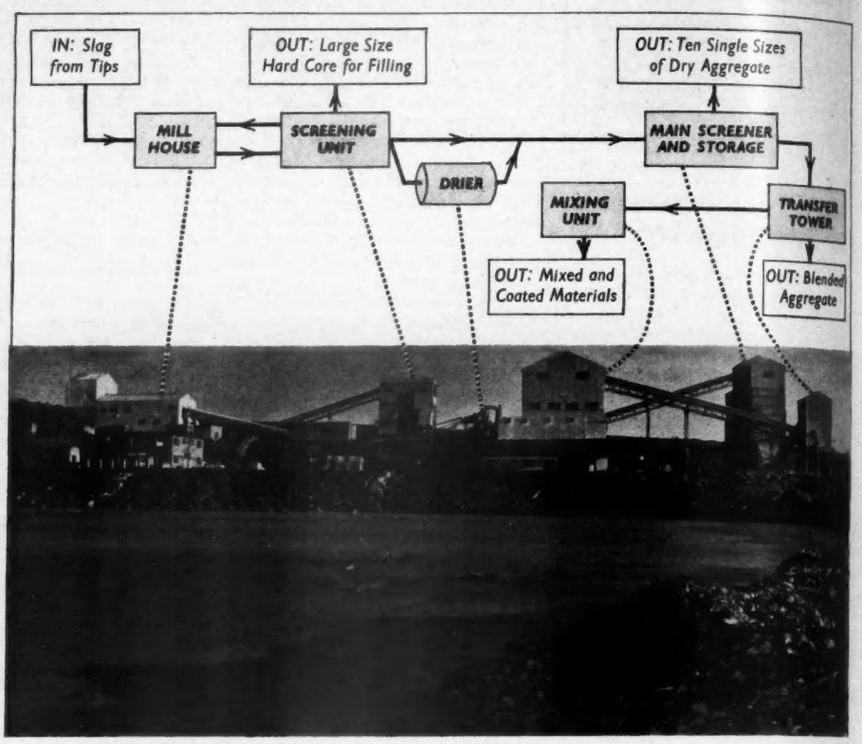
This plant has several interesting features. First, in its capacity. Slag dumps had been slowly approaching the coastline at Port Talbot, and when this project was envisaged, the sea washed up against a cliff of slag at high tide. Every week the five blast furnaces were turning out a total of over 16,000 tons of slag and this was collecting at quite an alarming rate. This new crushing and grading plant will cope with up to 110 tons of slag an hour, so that working a one shift day, it would be possible to process just under a half of the steel company's output, should the demand for the final product ever rise to such proportions. If all the slag proved suitable with regard to chemical composition—which is a state seldom attained in practical iron and steel making—it would theoretically be possible to cope in a 24 hour day with the whole output, and even to clear away some of the past years' accumulation.

Three firms have been primarily concerned with this project. Steel Company of Wales and G. Wimpey and Company jointly created and own the new company called Margam Slag; while Stothert and Pitt designed and erected the mechanical plant. You can obtain quite concise dats on the various parts of the plant and an idea of where they fit in with one another by reading the table and looking at the diagram above the illustration.

During the 12 months after the decision was taken to go ahead with the plant—in December, 1959—10,000 tons of blast furnace slag were used for site filling every week; in fact, the new plant is built completely on a bed of blast furnace slag. The company's object was to load the sand dunes with as much fill as possible in order to take up the expected settlement of a 1 to 2 ft layer of peat, 20 ft below the sand.

Plant Characteristics

Blast furnace slag output	16,500 tons per week
Train ladles	20 tons each Normal train 6 to 9 ladles every 2 to 3 hours
Slag cooling pits	
Capacity	60,000 tons
Digging machines	54 RB, 43 RB
Internal transport	AEC lorries, 12 tons capacity
Mill house	
Receiving hopper capacity	25 tons
Magnets	Rectangular type 54 in by 36 in, 18 in clearance
Primary crusher	Kue Ken Jaw Crusher, 42 in by 25 in 60 hp, 3 in to 4 in setting, output 110 tons per hr
Secondary crusher	Symons 3 ft extra coarse standard cone crusher, 60 hp, 1 in setting
Tertiary crusher	Symons 4 ft short head cone crusher 150 hp, ½ in setting
Max. crushing capacity	110 tons per hr of −¾ in of which 90 tons per hr would be −½ in
Selector screening unit	
Screen	Symons Double Deck 5 ft by 16 ft
Compartments	four, 25 tons capacity each
Sizes	+2½ in −2½ in +1½ in, −1½ in +¾ in, − ¾in
Rotary pre-dryer	drying material from −¾ in compartment
Screening and storage unit	
Screens	four Symons, 4 ft by 14 ft
Storage capacity	120 tons per size. Total 1,200 tons
Automatic proportioners	ten
Batching accuracy	±½ per cent
Screen sizes	−2½ in +1½ in, −1½ in +1¼ in, −1¼ in +1 in − 1 in + ¾ in, − ¾in +½ in, −½ in +⅜ in −⅜ in +¼ in, −¼ in, +⅛ in, −⅛ in +¼ in and −¼ in
Mixing unit	
Heating	twin batch
Batch weigh hopper capacity	60 cu. ft each
Batch heater capacity	60 cu. ft each
Batch heater power	35 hp each
Batch mixer capacity	60 cu. ft each
Batch mixer power	75 hp each
Mixing capacity	100 to 130 tons per hr
Mixed storage capacity	18 to 20 tons each in 6 hoppers
Filler capacity	7½ cu. yd
Binder storage	3 types each 6,000 gal capacity temperature thermostatically controlled
Oil fuel storage capacity	6,000 gal capacity
Flux oil storage capacity	3,000 gal capacity
Water storage capacity	3,000 gal capacity



At high tide sea laps against a foundation of blast furnace slag used for site filling.

The area had an original level of about 10 ft above ordnance datum and the site was prepared to two basic levels, one at 24 ft and the other at 44 ft, both 4 ft below final site level. Margam Slag report that no record of settlement has been made to date.

This two-level layout is rather unusual, as is turning of the flow line back on itself. The basic idea is that buildings needing personnel should be grouped near one another around a central administration and control laboratory block. From the services point of view it means that several power lines have been kept desirably short—such as from the substation to the 150 hp crusher motors. It can be seen that material enters at one level and leaves at a lower level, and this forced segregation of vehicle traffic is thought desirable. One difficulty could have been noise, but the administration building at least is quiet.

The main design philosophy was to create a plant from which aggregates of single or mixed sizes could be taken largely from stock or be produced at a very fast rate without producing unhandleable quantities of other sizes. Also, the mixer and coater plants were to be matched in throughput with the crusher and grader plants, so that macadam could be produced almost automatically to very tight specifications at the rates demanded by modern carpet layers. This seems to have been achieved.

There are three crusher stages. Each of these is used at reductions of less than 4 to 1 and this is said to give a desirable cubical shape to the aggregate. Magnetic separators remove iron lumps and thus prevent damage to crushers and other equipment, while producing an end-aggregate which will not stain concrete.

A rotary dryer near the first screening unit can be used to dry out fines, but can be by-passed by larger material as required. The preheater in the mixer and coater plant can thus be used for its main job of warming the aggregate before addition of binders, and the dangers of overheating and time delays through having to dry out the aggregate at this later stage are avoided.

The bins and main screens have been made as large as possible and the screens are arranged for progressive selection, rather than rejection, which is said to give low chute wear. Blends of aggregates are produced from a mixer console with automatic selector tablets for standard mixes. Quantities are metered by "paddle feeding" from the bins for set times, and an empty bin, or bridging in one of them, is detected by check weighing a total mixer change. However, this should never occur. Burners in the coater preheaters are said to be of novel, economic design, operating at higher temperatures than hitherto, and able to burn 200 seconds Redwood oil.

In discussion which followed a visit of the Institution of Municipal Engineers to this plant, members of the staff of Margam Slag Company were asked for frank comments on the value of blast furnace slag as a road aggregate. The answers included the following main points.

At an average specific gravity of 2·3, the coverage ton-for-ton is roughly 10 per cent higher than is possible with an average limestone. It is very good for sub-base and bases and should be good also for dressing (where it can be economically transported to site) although it crushes slightly under the roller. BS 594:1958 is almost certainly about to be amended so that asphalt can be made with all-slag aggregate, including fines. For water-bound tar macadams, the sulphur content is kept well below the trouble mark for efflorescence. Also there should not be any trouble in frosty weather, although one Newport engineer at the meeting said he had experienced slipperiness.

Margam Slag Company Limited, Abbey Works, Port Talbot, Glamorgan.

Nail-it-on Magnetic Strip

A magnetic strip is now being marketed in this country by the Eclipse organisation. It consists of magnetic powder in a pvc plastic body and is thus semi-flexible and can be cut or drilled.

The section of the strip is $\frac{1}{8}$ in by $\frac{11}{64}$ in and the flat face with a small groove along the centre provides the main magnetic face. It is magnetised continuously in a transverse manner so that any or all of the strip can be used as a magnet and pieces can be joined end to end. The attractive force when placed up against sheet steel depends on the separation (by paint films or paper for instance) but is roughly 3 ounces per inch of strip with no clearance and just half this figure at a distance of 0·015 in.

So here then is a flexible magnet which can be glued or nailed just where two surfaces must be held together. The makers have thought out many uses which include the following: door closures, hold-down strips, holders for steel components such as nuts and bolts, magnetic sump swarf collectors, a masking medium for paint spraying, temporary buffers (the plastic will absorb impacts), and markers for progress charts.

The pvc will begin to soften at about 70° C and there is no danger of the material losing its magnetism as the plastic itself will disintegrate before this happens (at an even higher temperature). Magnetism in the powder has very good properties and should be permanent for long periods. The material can be bent around a radius of about 3 in cold and can be deformed permanently after warming it up to soften. On the retail market it will cost about 2*s* a foot and will come in normal lengths of 12 ft.

James Neill and Company (Sheffield) Limited, Sheffield 11.

Lead Plywood Screens X-Rays

New X-ray resistant doors, partitions and wall panels have recently been fitted in the radiography departments of Queen Mary's and Plaistow Hospitals in East London. They are made from Lead Plymax, a composite material of sheet lead faced with plywood, and are the first of a series of similar installations to be made in all the six hospitals governed by the West Ham Group Management Committee.

Ministry of Health regulations regarding the shielding of X-ray installations, brought into force two years ago, require the room containing the source equipment to be isolated by a material that effectively blocks stray radiation. At Plaistow, panels of the material have been attached to walls and to wood and plasterboard partitions, and it has also been made up into doors.

Plymax, made by Venesta Plywood, consists of sheet lead $1\frac{1}{2}$ mm thick faced on both sides with, for the panelling, $\frac{1}{4}$ in plywood and, for the doors, $\frac{3}{8}$ in plywood. Though slightly more expensive than the chief alternative for installations of this type, barium plaster, it is expected to prove a good deal more durable. And the panels have the great advantage of being easily movable—there will be no difficulty in shifting them to another site if at any time the layout or position of the X-ray department has to be changed.

Venesta Plywood Limited, Queen Street Place, London, EC4.

Thinner Plaster Protects Steelwork

New tables showing revised thicknesses of vermiculite/gypsum plaster for fire protection of structural steelwork have been calculated by the Fire Research Station following a fresh series of tests on stanchions and beams carried out in accordance with BS 476 : 1953.

For the first time ratings for columns and beams are shown separately and it is noted that the thicknesses required for beams are considerably less than for columns. The thicknesses for columns are, in turn, less than those previously quoted. For instance, for 4 hour protection $1\frac{1}{2}$ in is now required whereas previously it was $2\frac{1}{4}$ in, and for 2 hour protection $\frac{3}{4}$ in instead of 1 in.

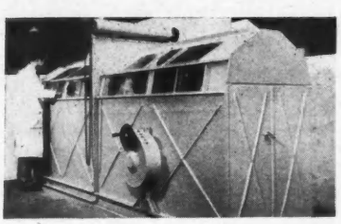
In the case of the 3 and 4 hour ratings for column encasement, the metal lath was spaced 1 in from the face of the flange by means of a light metal channel. Thicknesses of $1\frac{1}{4}$ and $1\frac{1}{2}$ in are therefore valid only for this form of construction.

In all cases the mixes were $1\frac{1}{2}$ volumes of coarse vermiculite plaster aggregate to 1 volume of retarded hemihydrate plaster for the rendering and floating coats, and $\frac{1}{2}$ volume of retarded hemihydrate plaster for the finishing coat.

The Expanded Metal Company Limited and Mandoval Limited, who undertook the research programme, have given permission to the Fire Research Station to use these results in any way they see fit. It is expected that they will be included in forthcoming revisions of the Scottish, LCC and Model Bye-Laws.

Dust Cabinet of Reinforced Polyester

The cabinet shown below was designed by E. A. Yates-Owen for the remote mechanical handling of steel drums in a beryllium plant. It is made by Parglas from glass reinforced plastics. The main operation carried out in the cabinet is



drawing dust off the drums by a vacuum process, after which they are passed through sliding doors for washing and cleansing.

Other items fabricated by Parglas from this material are a rotary seal for a provender mill and a venturi for use in the acid plant of a large chemical works. For the cabinet, a general purpose polyester resin was reinforced with Duramat chopped strand mat and acrylic fibre, while the venturi was made with epoxy resins reinforced mainly with Duraglas woven rovings.

Duramat and Duraglas by Turner Brothers Asbestos Company Limited, PO Box 40, Rochdale.

Silicone Grease in Aerosol Pack

A silicone grease used for protecting and insulating ignition systems and electrical equipment is now being marketed in an aerosol pack, under the name MS4, by Amber Oils. This method of packing provides a means of applying the grease without handling. Penetration is good and the film so formed is said to be thin and even.

MS4 is a product of Midland Silicones, and has good dielectric properties as well as being highly water-repellent and oxidation resistant. Its working temperature range is from − 50° C to 200° C. It readily adheres to the dry surfaces of metals, ceramics, rubber and other insulating materials, giving them high surface resistivity to tracking and the effects of corona discharge.

Amber Oils Limited, 11a Albemarle Street, London, W1.

Sealant Resins

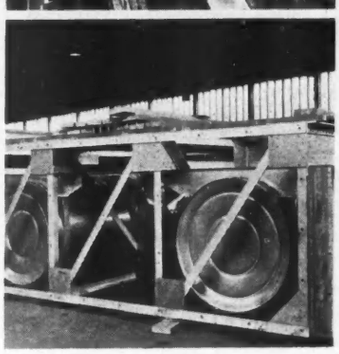
A mistake crept into our article on sealant resins (27 Jan. '61, p. 134) for which we apologise. Small Electric Motors Limited say that certain of the lower powered output motors made by them have the rotors attached to the rotor shafts with sealant resins. For all motors of higher power, however, they continue the standard method of attachment, either by pressing the rotors on to the shafts or by using a suitable key.

Aluminium Pontoon for Milford Haven

To reduce labour and expense of frequent maintenance, a pontoon built for the Esso Petroleum Company's marine terminal at Milford Haven is constructed almost entirely of aluminium. It was built by Whittingham and Mitchel.

With overall dimensions of 50 ft by 22 ft by 5 ft 3 in deep, the pontoon was fabricated in four sections and assembled on the site before lifting into place. The lower illustration shows some of the detail design—mainly consisting of 3 in by 3 in by $\frac{5}{16}$ in ordinary angles, with buoyancy provided by 24 cylindrical tanks of 3 ft 3 in diameter and 5 ft length.

The tanks were welded from 10 swg aluminium sheet and each has a trunked manhole for access and two transverse internal diaphragms. They are suspended from yokes by aluminium straps so



that their buoyancy in the water helps hold them in position. All the aluminium was supplied by Alcan Industries.

Stainless steel bolts are used to assemble the three separate sections of the pontoon, and the hardwood sheathing which covers the deck and sides is bedded in bitumen where it comes into contact with the aluminium structure. In addition to the hardwood sheathing, a heavy elm fender is fitted along each side. Total weight of the pontoon, which floats at a light draught of 1 ft 9 in, is about 17 tons and weight of the aluminium structure about 5 tons. Reserve buoyancy is about 20 tons.

In the top illustration are shown the vertical steel guides in which the pontoon moves with the tide. The gangway with self-levelling steps, also made by Whittingham and Mitchel, is fabricated in aluminium alloy.

Alcan Industries Limited, Banbury, Oxon.

Plain Words

By Capricorn

"ADMINISTRATION takes so much of my time these days I hardly have a moment for fundamental work." How often I have heard the leaders of research teams complain along these lines. It sounds as if we're wasting a lot of costly training and experience. But are we?

At first, when I read about Professor R. Edgeworth Johnstone's survey on the extent to which chemical engineers made use of academic subjects I was very disturbed. From the report in ENGINEERING on 3 February it appeared that many chemical engineers in responsible positions spent most of their time drafting reports, managing other people or applying economics. They used their academic disciplines up to about school "O" or "A" level. Why bother at all, I wondered?

But then I thought again. Men are paid high salaries for taking responsibility, for making big decisions and for having an accurate intuitive judgment. These tasks take clarity of thought, experience and commonsense. They require a breadth of outlook and an ability to grasp the significance of fields not closely related to one's own.

To be able to draft well is to be able to think clearly, to argue cogently and to phrase diplomatically. To manage others is to have certain characteristics of leadership, to have the confidence to delegate and to lay down systematic ways of working. To apply economics is to have intellectual flexibility and the ability to draw on other disciplines.

School level clearly isn't quite enough. The necessary qualities are only acquired by a man who has absorbed a subject thoroughly, has been disciplined by it and has attained a certain academic (not necessarily university) standard of performance and has taken the conscious decision not to be a specialist—not that there is anything wrong with specialism in the right context. They are the sum total of a widely based man in maturity.

I can remember when I was a new graduate trying desperately to solve certain problems by trying to fit them into a framework of complicated theory which just would not take them. A few years' experience and a little more judgment and confidence to make a leap in the dark would have pulled it off. These things come, at least in some measure, in time.

The further an engineer goes, the more he is likely to draft and manage, and rightly so. He is a man carrying responsibility who has been educated in the broadest sense. The highly qualified specialist apart, it will be a bad day for engineering when its top men cannot draft well, cannot manage imaginatively and cannot use economics, sociology or any other discipline as an instrument, like a slide rule.

And conversely, if engineers do not sometimes become poets, publicans, painters or politicians I shall be very much surprised—and disappointed.

Letters to the Editor

Pressure Vessel Codes

SIR, May I refer to your article "Do Pressure Vessel Codes Need Unifying?" (ENGNG., 10 Feb. '61, p. 238).

While agreeing with the general sentiments expressed in the body of that article concerning the advantages of one code in the place of three or more codes, I do consider there has been a tendency on your part to put the cart before the horse. The main impression left after reading this article and Mr. J. F. Lancaster's original paper is the urgent and crying need for revision of the working stresses to which pressure vessels are designed, and not the need for the unification of United Kingdom codes.

It is advanced that unification of our own codes is urgent, and that the benefits of such unification would produce economies of manpower in design, on the shop floor and for inspection. Undoubtedly all these benefits would be effected but I venture to suggest that if, tomorrow, we had a unified code, then the cost of a pressure vessel to the user would not be lowered by 1 per cent.

Pressure vessels are not mass-produced articles and ready waiting to be bought "off the shelf." Generally speaking, each pressure vessel has to be individually designed and the use of three codes instead of one does not involve a large increase in design time or shop time. It does involve, however, an increase of stored knowledge, particularly with regard to detail on the part of the personnel involved; but a reduction in this would not result in large economies in cost.

On the other hand, a change in the fundamental design stress directly involves probably 90 to 95 per cent of the weight of material used in the completed vessel and, consequently, can lead to very important differences in the cost to the buyer. In one case alone, the difference in the cost of vessels designed to United Kingdom codes and Continental codes was £300,000: £180,000. The weights of the vessels were roughly in the same proportion.

Obviously, United Kingdom suppliers of plant involving pressure vessels are at a disadvantage against Continental suppliers in the world export market. Also, it would appear that we are producing pressure vessels for home use which are stronger and heavier and, consequently, wasteful in material and manpower when compared with some Continental countries.

As you have pointed out, the reason for this possible reduction of weight and cost of vessels, follows because of the method of computing design stresses. United Kingdom and United States methods use $\frac{UTS}{4}$ and Continental (German and Scandinavian) $\frac{\text{Hot Yield}}{1{\cdot}5}$ to determine the design stress up to 650° F. At 650° F, these two methods tend to coincide and give similar results, but, at lower temperatures, down to ambient temperature, the difference is very marked and can lead to a reduction of thickness of up to 35 per cent. Another very important effect of this change of design-stress basis is that the full advantage of low-alloy high-yield steels can be utilised. On the basis of $\frac{UTS}{4}$, such steels, in many cases, show little economic advantage over mild steels, but the picture is very different on a yield basis.

Much research work has been devoted to pressure-vessel design methods during the last two decades, including the investigation of high-strain fatigue and the capability of vessels to operate under higher stress conditions. Light has been thrown on the effects of elastic stress concentrations. Out of it all comes the one definite realisation that, in fact, the actual stresses in pressure vessels (which have worked satisfactorily), have been much larger than the apparently low nominal design stresses.

But, to utilise this growing body of knowledge, the basis of design stress must be reconsidered and rationalised, and brought into line with modern thinking and experience. The anomalous position exists at the moment that a mild-steel vessel "safely" designed to United Kingdom codes and requiring a thickness of 1½ in for a given pressure and temperature (say 250° F) would only need to be perhaps 1 in in thickness if built in Germany to their national code. Yet the Germans appear to have satisfied themselves that the reduced thickness is adequately safe. Also, they have been doing this since 1941.

It is realised that changes of this sort require very serious consideration, but surely this matter of a proper design stress basis is one which the engineers of this country are quite capable of evaluating and resolving. The benefits are so important in the long run, that every effort should be made to meet this challenge and give an authoritative answer to the question of whether a pressure vessel with wall thicknesses of 2/3 or less of those presently thought safe in this country is, in fact, safely and adequately designed.

Further. I feel this is a matter for engineers to decide and I suggest that the Institution of Mechanical Engineers would be the proper body to sponsor and direct such an investigation.

Yours faithfully,
JOHN W. BURRILL.

London, W2.
24 February, 1961.

Events in Advance

Institute of Welding, Spring Meeting.—Tues., 25 April, to Fri., 28 April, in London. General theme: "Recent Developments in the Welding and Allied Processes." Offices of the Institute: 54 Princes Gate, Exhibition Road, South Kensington, London, SW7. Tel. KNIghtsbridge 8556.

European Agricultural and Industrial Fair (ELMIA 61).—Thurs., 25 May, to Sun., 4 June, at Jönköping, Southern Sweden. In the United Kingdom, apply to the agents: Empson and Turner Ltd., Thorn House, Upper St. Martin's Lane, London, WC2. Tel. TEMple Bar 9081.

Liége International Fair (Mining and Industrial Machinery), 13th.—Sat., 27 May, to Sun., 11 June, in Liége, Belgium. Agent in the United Kingdom: Mr. R. C. Liebman, 178 Fleet Street, London, EC4. Tel. CITy 5889.

Samples and Packaging Salon, International.—Mon., 29 May, to Tues., 13 June, in Padua, Italy. Agents in the United Kingdom: Fairs and Exhibitions Ltd., 2 Dunraven Street, Park Lane, London, W1. Tel. HYDe Park 5421.

Lisbon International Trade Fair.—Fri., 9 June, to Fri., 23 June, in Lisbon, Portugal. In the United Kingdom, applications should be made to the Casa de Portugal, State Information and Tourist Office, 20 Lower Regent Street, London, SW1. Tel. WHItehall 2455.

American Society of Mechanical Engineers, Annual Summer Meeting.—Sun., 11 June, to Thurs., 15 June, at the Statler Hilton Hotel, Los Angeles, California, USA. Offices of the Society: 29 West 39th Street, New York 18, USA.

Newcomen Society: Summer Meeting.—Sun., 11 June, to Sat., 17 June, in Sweden. Offices of the Society: Science Museum, South Kensington, London, SW7. Tel. KENsington 1793.

Medical Exhibition.—Mon., 12 June, to Fri., 16 June, at Princes Hall, Broad Street, Birmingham. Apply to the Exhibition Organiser, British and Colonial Druggist, Ltd., 194-200 Bishopsgate, London, EC2. Tel. AVEnue 1444.

Institution of Electrical Engineers: South Midland Centre's Diamond Jubilee Celebrations.—Tues., 20 June, to Thurs., 22 June, in Birmingham and the surrounding district. Apply to Mr. J. C. Pyatt, Central Electricity Generating Board, Nechells 'B' Power Station, Nechells, Birmingham 7.

Trieste International Samples Fair.—Wed., 21 June, to Wed., 5 July, in Trieste, Italy. In the United Kingdom, applications should be made to the Italian Chamber of Commerce for Great Britain in London, 31 Old Burlington Street, London, W1. Tel. REGent 2411.

Royal Norfolk Agriculture Show.—Wed., 28 June, and Thurs., 29 June, at the Showground, Norwich.

Organised by the Royal Norfolk Agricultural Society, Diss, Norfolk.

Malta Trade Fair, Fifth.—Sat., 1 July, to Sat. 15, July, in Valletta. Organised by the Malta Fair Corporation, Exchange Buildings, Valletta, Malta.

Messina International Samples Fair.—Sun., 6 Aug., to Mon., 21 Aug., at Messina. Apply to the Ente Autonome Fiera di Messina, Messina, Italy.

Radio and Television Exhibition, 28th National.—Wed., 23 Aug., to Sat., 2 Sept., at Earl's Court, London, SW5. Organised by Radio Industry Exhibitions Ltd., 59 Russell Square, London, WC1. Tel. MUSeum 6901.

Leather Goods Trade Fair.—Sat., 2 Sept., to Thurs., 7 Sept., in Offenbach. Organised by Offenbacher Messe-Gesellschaft m.b.H., 110 Kaiserstrasse, Offenbach-on-Main, Germany.

European Fair, 36th.—Sat., 2 Sept., to Sun., 17 Sept., at Strasbourg. Organisers: Foire de Strasbourg, 9 Rue Brulée, Strasbourg.

Frankfurt International Autumn Fair.—Sun., 3 Sept., to Thurs., 7 Sept., in Frankfurt. Agents in the United Kingdom: Lep Transport Ltd., Sunlight Wharf, Upper Thames Street, London, EC4. Tel. CENtral 5050.

Leipzig International Autumn Fair.—Sun., 3 Sept., to Sun., 10 Sept., in Leipzig. Applications in the United Kingdom should be sent to the Leipzig Fair Agency in Great Britain, 39 St. James's Place, London, SW1. Tel. HYDe Park 3111.

German Welding and Cutting Exhibition.—Sun., 3 Sept., to Sun., 10 Sept., in Essen. Organised by the Gemeinnutzige Ausstellungs-G.m.b.H., 2 Norbertstrasse, Essen, Germany.

European Machine Tool Exhibition, Seventh.—Sun., 3 Sept., to Tues., 12 Sept., at Centenaire Palaces, Brussels. Organised by the Syndicat des Constructeurs Belges de Machines-Outils pour les Travaux de Metaux (SYCOMON), 13 Rue des Drapiers, Brussels 5, Belgium. In the United Kingdom, information is obtainable from the Machine Tool Trades Association, Brettenham House, Lancaster Place, London, WC2. Tel. TEMple Bar 3606.

Salonika International Trade Fair.—Sun., 3 Sept., to Sun., 24 Sept., in Salonika. Apply to the Organising Committee, Fair Office, Thessalonika.

Plasma Physics and Controlled Nuclear Fusion Research, Conference.—Mon., 4 Sept., to Fri., 8 Sept., at Salzburg, Austria. Apply to the International Atomic Energy Agency, Kaerntnerring, Vienna 1, Austria.

Discovery of the Nucleus, International Conference on (Jubilee Celebration).—Mon., 4 Sept., to Sat., 9 Sept., at Manchester. Organised by the Institute of Physics and the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, SW7. Tel. KENsington 0048.

Meetings and Papers

Association of Supervising Electrical Engineers

LONDON
"Electrical Installations for Large Industrial Projects," by Sir Henry Clay, Bt. At the 10th Electrical Engineers (ASEE) Exhibition, Cromwell Hall, Earls Court, SW5. Wed., 22 Mar., 6.30 p.m.

British Institution of Radio Engineers

LONDON
"Electronic Instrumentation for Nuclear Power Stations": a symposium of six papers. London School of Hygiene and Tropical Medicine, Keppel Street, WC1. Wed., 29 Mar., 3 p.m.

British Interplanetary Society

BIRMINGHAM
"Some Astronomical and Astronautical Aspects of the Moon," by K. Fea. Midlands Branch. Birmingham and Midland Institute, Paradise Street, Birmingham. Sat., 8 April, 6.30 p.m.

Building Centre

LONDON
Films: "Area Service" and "Service to Industry," exhibited by Yorkshire Imperial Metals Ltd. Wed., 5 April, 12.45 p.m.

Combustion Engineering Association

LONDON
"New Designs and Techniques in the Construction of Water Tube Boilers," by Dr. Ing. Heinrich Vorkauf. Criterion Restaurant, Piccadilly Circus, SW1. Wed., 29 Mar., 2.15 p.m.

Engineers' Guild

SOUTHEND
"The Guild Conference and Matters of Interest to Professional Engineers," by D. E. Glover. Essex Branch. Middleton Hotel, 119 High Street, Southend. Tues., 28 Mar., 7.30 p.m.

Illuminating Engineering Society

NEWCASTLE UPON TYNE
"Design Criteria for Integrated Lighting in Buildings," by Derek Phillips. Newcastle upon Tyne Centre. The Percy Building, King's College, Queen Victoria Road, Newcastle upon Tyne 1. Wed., 5 April, 6.15 p.m.

NOTTINGHAM
"Ship Lighting," by A. E. Fothergill. Nottingham Centre. Electricity Centre, Carrington Street, Nottingham. Thurs., 6 April, 6 p.m.

Institute of Marine Engineers and Royal Institution of Naval Architects

SOUTHAMPTON
"Novel Concepts in Marine Transport," by P. R. Crew. Southern Joint Branch. Technical College, Southampton. Mon., 27 Mar., 7.30 p.m.

Institute of Marine Engineers

NEWCASTLE UPON TYNE
"Materials for Advanced Steam Conditions and Their Influence on the Operation of Turbines and Boilers," by Commander H. E. C. Hims and S. H. Frederick. North East Coast Section. Stephenson Building, King's College, Claremont Road, Newcastle upon Tyne. Thurs., 30 Mar., 6.15 p.m.

Institute of Metals

LONDON
"Physical Methods of Analysis for Major Alloying Constituents," by K. M. Bills, at 6.30 p.m. Preceded by the Section's annual general meeting, at 6 p.m. London Local Section. Thurs., 6 April.

BIRMINGHAM
Annual General Meeting. Birmingham Local Section. College of Technology, Gosta Green, Birmingham. Thurs., 6 April, 6.30 p.m.

OXFORD
"Ductile Fracture," by Professor R. W. K. Honeycombe. Preceded by the Section's annual general meeting. Oxford Local Section. Cadena Café, Cornmarket Street, Oxford. Tues., 4 April, 7.15 p.m.

Institute of Petroleum

LONDON
"Airborne Techniques in Petroleum Exploration," by Dr. W. Domzalski. Wed., 5 April, 5.30 p.m.*

Institute of Refrigeration

LONDON
"Results of Practical Experiments on Relative Humidity Control," by J. A. Cox. Institute of Marine Engineers, 76 Mark Lane, EC3. Thurs., 6 April, 5.30 p.m.*

Institute of Road Transport Engineers

CARDIFF
Annual General Meeting. South Wales Centre. South Wales Institute of Engineers, Park Place, Cardiff. Fri., 7 April, 7.15 p.m.

Institution of Chemical Engineers

LONDON
"A Systematic Classification of Chemical Processes and Equipment," by K. Fischbeck. Society of Chemical Industry, 14 Belgrave Square, SW1. Tues., 11 April, 6 p.m.

Institution of Civil Engineers

LONDON
"River Utilisation and the Preservation of Migratory Fish Life," by G. Baxter. Thurs., 6 April, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
"Technical and Economic Aspects of the Supply of Reactive Power in England and Wales," by W. Casson and H. J. Sheppard. Thurs., 6 April, 5.30 p.m.*
"The Conversion of Biological Data into Electrical Signals:" Discussion. Medical Electronics Discussion Group. Fri., 7 April, 6 p.m.*

ABERDEEN
"Some Considerations in the Application of Power Rectifiers and Converters," by J. P. McBreen. North Scotland Subcentre. Robert Gordon's Technical College, Aberdeen. Fri., 14 April, 7.30 p.m.

DUNDEE
"Some Considerations in the Application of Power Rectifiers and Converters," by J. P. McBreen. North Scotland Subcentre. Electrical Engineering Department, Queen's College, Dundee. Thurs., 13 April, 7 p.m.

EDINBURGH
"A General Theory of Depreciation of Engineering Plant," by D. Rudd. South East Scotland Subcentre. Carlton Hotel, Edinburgh. Tues., 4 April, 7 p.m.

NEWPORT (I.O.W.)
"Subscriber Trunk Dialling," by D. A. Barron (to be read by H. E. Francis). Southern Centre. Offices of the Southern Electricity Board, Newport, Isle of Wight. Fri., 7 April, 6.30 p.m.

PORTSMOUTH
"Application of Electronics to the Electricity Supply Industry," by Dr. J. S. Forrest: Third Hunter Memorial Lecture. Annual General Meeting. Southern Centre. Main Hall, College of Technology, Portsmouth. Wed., 5 April, 6.30 p.m.

Institution of Engineering Inspection

LONDON
"Some Aspects of Specifications and Tolerances," by R. H. S. Lesser. London Branch. Royal Society of Arts, John Adam Street, Adelphi, WC2. Thurs., 30 Mar., 6.45 p.m.*

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Cavitation Tunnel Tests with Merchant Ship Propellers," by H. B. Lindgren. Annual General Meeting. Tues., 11 April, 6.30 p.m.

Institution of Heating and Ventilating Engineers

CARDIFF
"The Work of the Heating and Ventilating Research Association," by N. S. Billington. South Western Branch. Offices of the General Electric Co. Ltd., Cardiff. Tues., 4 April, 6.30 p.m.

LEICESTER
Annual General Meeting. East Midlands Branch. Grand Hotel, Leicester. Wed., 5 April, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
"Is Fuel-Injection-Equipment Standardisation Limiting the Development of Small Diesel Engines?" Discussion, to be introduced by L. Waters. Internal Combustion Engines Group. Mon., 27 Mar., 6 p.m.*
"Application of the Flash Temperatures Concept to Cam and Tappet Wear Problems," by A. Dyson and Dr. H. Naylor. Automobile Division. Tues., 11 April, 6 p.m.*

CARDIFF
"Automobile Engineering": symposium. South Wales Branch. South Wales Institute of Engineers, Park Place, Cardiff. Wed., 5 April, 2.30 and 6 p.m.

IPSWICH
"Common and Uncommon Causes of Failure of Plant in Service," by G. A. Cottell. Annual Meeting. Eastern Branch. Diocesan Hall, Ipswich. Thurs., 30 Mar., 7.30 p.m.

LINCOLN
"Powder Metallurgy Applications," by B. H. Swan. East Midlands Branch. Technical College, Lincoln. Thurs., 30 Mar., 7.15 p.m.

Institution of Plant Engineers

BOURNEMOUTH
"Radioactive Isotopes in Industry": Discussion. Southern Branch. Grand Hotel, Bournemouth. Wed., 5 April, 7.30 p.m.

COVENTRY
"Colour in the Home": Discussion. Birmingham Branch. Hotel Leofric, Coventry. Tues., 11 April, 7.30 p.m.

EDINBURGH
Hydro-Electric Power Stations, described in "Highland Journey": film and commentary, by A. Baillie. Edinburgh Branch. Heriot-Watt College, Chambers Street, Edinburgh. Wed., 5 April, 7 p.m.

PETERBOROUGH
"Factory Electrical Distribution Systems," by J. H. Quick. Peterborough Branch. White Lion Hotel, Church Street, Peterborough. Tues., 4 April, 7.30 p.m.

Institution of Production Engineers

BRIGHTON
"Rockets and Rocket Propulsion," by L. S. Snell. Old Ship Hotel, King's Road, Brighton. Wed., 5 April, 7 p.m.

Junior Institution of Engineers

LONDON
"A New Theory of the Origin of the Planetary System," by Professor R. O. Kapp. Fri., 24 Mar., 7 p.m.*

Newcomen Society

LONDON
"Windmills of Derbyshire, Leicestershire and Nottinghamshire: Part I—Post Mills," by P. H. J. Baker and Rex Wailes. Wed., 5 April, 5.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE UPON TYNE
"Oil Firing, with Particular Reference to Marine Application," by G. R. Gray. Neville Hall, Westgate Road, Newcastle upon Tyne. Fri., 7 April, 6.15 p.m.

Reinforced Concrete Association

BRISTOL
"Ready Mixed Concrete," by Victor S. Wigmore. West of England Branch. New School of Engineering, The University, Bristol. Thurs., 6 April, 6 p.m.*

Royal Aeronautical Society

LONDON
"Development of Stabilising Equipment for Helicopters," by P. D. MacMahon. Rotocraft Section. Fri., 7 April, 7 p.m.

Royal Meteorological Society

LONDON
"The History of Meteorology," by Professor T. Bergeron. Wed., 5 April, 5 p.m.*

Sheffield Metallurgical Association

SHEFFIELD
"The Role of Ferro-Alloys in Modern Steelmaking Developments," by A. M. Sage. BISRA Laboratories, Hoyle Street, Sheffield. Tues., 28 Mar., 7 p.m.

Society of Instrument Technology

FAWLEY
Annual General Meeting and Film Evening. Fawley Section. Administration Building, Esso Refinery, Fawley. Fri., 7 April, 5.30 p.m.

West of Scotland Iron and Steel Institute

GLASGOW
"Heating and Oxidation in the Basic Open-Hearth Process," by I. M. Mackenzie, D. Hadfield, T. Urie and Mrs. A. Donald. Fri., 14 April, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. An asterisk (*) is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, WC1. (LANgham 5927)
British Institution of Radio Engineers, 9 Bedford Square, London, WC1. (MUSeum 1901)
British Interplanetary Society, 12 Bessborough Gardens, London, SW1. (TATe Gallery 9371)
Building Centre, 26 Store Street, London, WC1. (MUSeum 5400)
Combustion Engineering Association, 70 Jermyn Street, St. James's, London, SW1. (WHItehall 5536)
Engineers' Guild, 201 High Holborn, London, WC1. (HOLborn 1057)
Illuminating Engineering Society, 32 Victoria Street, London, SW1. (ABBey 5215)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, EC3. (ROYal 8493)
Institute of Metals, 17 Belgrave Square, London, SW1. (BELgravia 3291)
Institute of Petroleum, 61 New Cavendish Street, London, W1. (LANgham 3583)
Institute of Refrigeration, New Bridge Street House, New Bridge Street, London, EC4. (CENtral 4694)
Institute of Road Transport Engineers, 1 Cromwell Place, Kensington, London, SW7. (KENsington 3744)
Institution of Chemical Engineers, 16 Belgrave Square, London, SW1. (BELgravia 3647)
Institution of Civil Engineers, Great George Street, London, SW1. (WHItehall 4577)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. (COVent Garden 1871)
Institution of Engineering Inspection, 616 Grand Buildings, Trafalgar Square, London, WC2.
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C2. (Central 5181)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, SW1. (SLOane 3158)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, SW1. (WHItehall 7476)
Institution of Plant Engineers, 2 Grosvenor Gardens, London, SW1. (SLOane 0469)
Institution of Production Engineers, 10 Chesterfield Street, London, W1. (GROsvenor 5254)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, SW1. (VICtoria 0786)
Newcomen Society, Science Museum, Exhibition Road, London, SW7. (KENsington 1793)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle upon Tyne 1. (Newcastle 20289)
Reinforced Concrete Association, 94-98 Petty France, London, SW1. (ABBey 4504)
Royal Aeronautical Society, 4 Hamilton Place, London, W1. (GROsvenor 3515)
Royal Institution of Naval Architects, 10 Upper Belgrave Street, London, SW1. (SLOane 4622)
Royal Meteorological Society, 49 Cromwell Road, South Kensington, London, SW7. (KENsington 0730)
Sheffield Metallurgical Association, 64 Crescent Road, Sheffield 7. (Sheffield 52865)
Society of Instrument Technology, 20 Queen Anne Street, London, W1. (LANgham 4251)
West of Scotland Iron and Steel Institute, 39 Elmbank Crescent, Glasgow, C2. (Central 5181)

Scales for Coding Quantities Electrically

Data, to be processed automatically, must be translated into electrical equivalents. To measure quantities a variety of coded scales are used.

By D. S. Evans, M.I.E.E., Hilger and Watts Limited

THE term "binary coded scale" must have become very familiar to instrumentation engineers in all types of industries and to a great number of managers and operators alike. To many it will be just a classification, a description of a piece of equipment—the electrical equivalent of a visual scale—as indeed it is. But how many people realise the potentialities or limitations of what appears basically to be a simple device?

Also, the heartaches and searchings that have gone on, and to some extent are still going on, to produce a universally acceptable system are intriguing and by no means abstract. The arguments are mostly sound practical logic that can be understood by anyone who has the time or inclination to go into them. The fact that computers and mathematicians are involved at the receiving end need not put lay engineers off. The specialists are usually concerned with error correction or detection coding rather than the more common forms of coding in current use.

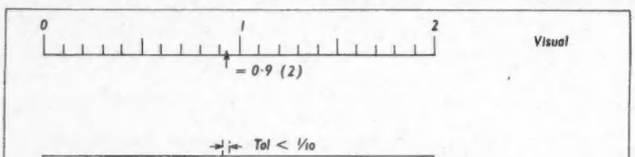


Fig. 1 (above) Comparison of visual and electrical scales.

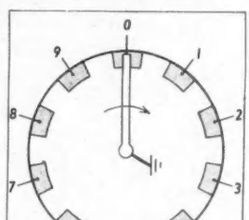


Fig. 2 Binary decimal switch.

A previous article, "Computers Make Sense on Scale of Two" (ENGNG., 7 Oct. '60, p. 474), showed the relation between the digital computer and the digital scale. Computers working entirely in the scale of two were assumed, though the inputs were binary coded decimal and the outputs decimal. A hotch potch to make life easier for the human operator! But of course there are special-purpose computers that work in decimal fashion and others that accept and deliver in the scale of two.

The one common factor in all the descriptions and discussions with which we are concerned is the term "binary." It is very often used to mean the "scale of two," but it is also used to mean "two state" and can therefore cause confusion. In referring to a "binary coded scale" we shall in this article be classifying the basic structure and not the radix or base. In other words the term binary will mean it is a "yes-no" or "on-off" arrangement represented symbolically by zeros and ones.

The digital coded scale can be regarded as the direct equivalent of the rule, meter face, tuning dial, and any other visual scale, since it too provides an indication of displacement. But there is one outstanding difference and that is in the way it is marked. For example, the rule, though uniformly divided is figured at each major line or division, each figure referring to a particular point on the scale only. The next figure is a whole major step away and again refers to a particular point. The subdivisions are unlabelled, the values being determined by the observer. On the other hand the electrical scale has no means of discrimination and each division and subdivision needs to be labelled, the labels covering the complete steps and not just an edge, so that it is perfectly continuous, as in Fig. 1.

With the visual scale a single fiducial line or pointer is sufficient to indicate the reading point for as many figures as the resolution and scale length will allow. For the electrical scale it is necessary to determine each figure separately since each figure is separately defined. The detectors must of course be carefully aligned to better than the smallest division.

In both the visual and electrical scales it is optional whether the scale moves and the pointer or detectors remain stationary or whether the reverse is adopted. In general, with coded scales, the scale is made to move, since detectors are connected by wires and if they themselves were to move sliprings would have to be introduced.

Each detector in an electrical scheme should only be expected to determine an "on" or an "off" condition and not an intermediate voltage level. This avoids errors which could be due to non-linear characteristics in the detectors, non-uniformity between detectors, fall off in transmission lines and so on.

Basically then the following rules need to be observed: (*a*) the scale shall be continuous; (*b*) detection shall be within the resolution of the scale; (*c*) each figure shall be individually determinded; and (*d*) each figure shall be binarily indicated.

One other very important consideration is that the scale readings must be non-ambiguous. The only doubt must be in the change from one complete reading to the next, namely in the least significant place.

It is quite possible to produce decimal scales which only have two states for each decimal digit. In fact the well known single-pole ten position switch answers this description. Fig. 2 shows such a switch and it will be noticed that the wiper or pointer moves while the contact plate or scale remains stationary.

Two equivalent arrangements are those of Figs. 3 and 4 where the detectors are held stationary and a scale is moved across them. Each circuit will be completed in turn as the scale is moved.

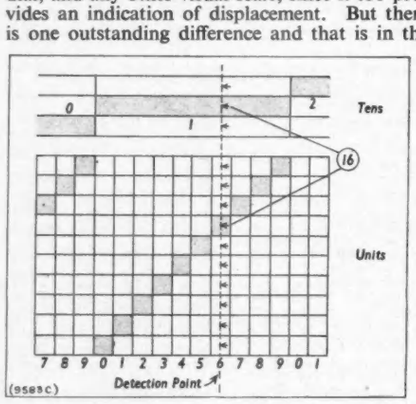


Fig. 3 (left) Binary decimal scale with single detection point

Fig. 4 (right) Binary detection scale with programme detection points.

These arrangements suffer from the fact that the contacts will either bridge two adjacent positions in the transition or they will break before making again. The first case produces ambiguities, due to the fact that two figures appear together, while the second produces gaps between figures, that is, a discontinuous scale. Neither of these conditions can be tolerated in a smoothly variable system of the type with which we are concerned; they can however be used in a stepped arrangement, such as a preset manual or rachet driven switch.

There are electrical methods for overcoming the defects mentioned. For example, the contacts can be duplicated and arranged in leading and lagging sets which can be selected alternately from a control track at half the pitch. As the scale is moved the switching produces a leap-frogging action, as if vaulting over the intersections, and is positive and fast enough not to appear as a break. This approach is shown diagrammatically in Fig. 5. Only one pair of lead and lag contacts is shown for simplicity.

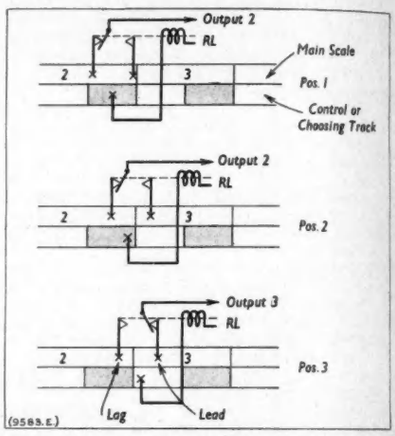


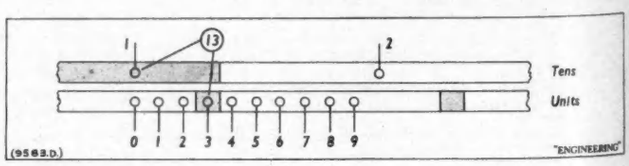
Fig. 5 Avoiding ambiguities by choosing.

Another method in use is to separate the odd figures from the even by introducing an odd-or-even track. In this case a single bridging main contact is used. Without the odd-or-even selection two adjacent figures would come up together. This system is illustrated in Fig. 6.

Decimal units have so far been confined in practice to very low resolution devices, mainly owing to the number of contact or detectors involved. Where resolutions of one part in 1,000 are concerned on one scale more than 30 individual circuits are required and the problem of condensing them into a small space is quite formidable and it is questionable whether they will compete with the coded varieties.

The small decimal units with six, ten or twelve divisions for one revolution are of great interest particularly as they are fitted with anti-backlash circuits and can be coupled by gearing one to another to form revolution indicators. The revolutions may represent the turns of a lead-screw, for example, or the revolutions of a minute shaft of a clock motor, so indicating time in minutes or hours and minutes, depending on the combinations used, as represented in Fig. 7. The outputs can be used for display or recording.

We have seen in the previous section that



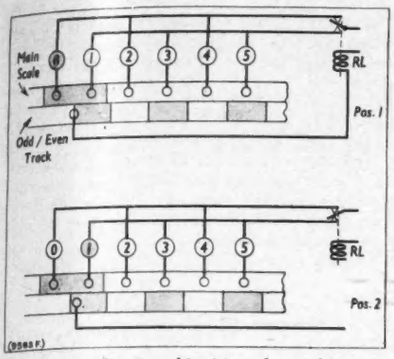


Fig. 6 Avoiding ambiguities by odd-or-even selection.

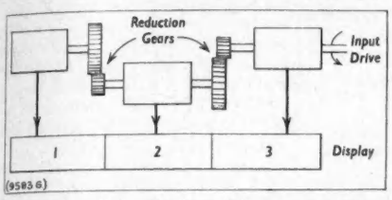


Fig. 7 Uncoded units in multiturn arrangement.

digital scales can be uncoded, and being able to work completely in decimal terms from digitiser to display or typewriter is very attractive. Unfortunately for us humans this is not always an economic proposition, particularly when several decades of information are required to be transmitted and stored, since each digit (ten per decade) requires its own store. We are thus brought right back to the arguments for the scale of two, or a compromise in the form of a binary coded decimal arrangement.

In the previous article, "Computers Make Sense on Scale of Two," brief mention was made of coded scales and three examples were given. There was also a brief mention of avoiding ambiguities by "choosing" (the exact equivalent of the method described above for decimal scales) and cyclic or reflected type scales, where only one digit track changes at a time. One or two points of interest arise in connection with the choice of scale patterns and some of these will now be described with reasons for their choice.

Since the scale of two is fundamentally the most economical arrangement of binary digits, with no redundancies, little more need be said about it apart from the fact that it is often rearranged so that there is only one digit or edge change at any one place. This pattern is a bridging, reflected or cyclic arrangement and is sometimes called a Gray code or Cyclic Permuted Binary (CPB). The two patterns are shown side by side in Fig. 8. It should be noticed that numerical values can no longer be given to the tracks of the cyclic permuted scale, so that it is a little more difficult to translate.

Scales which only change by one digit at a time are not necessarily cyclic. Balanced cyclic scales are those which when halved appear as back to back images, apart from one distinguishing digit, which runs throughout the length of one half. Without this digit or track, the scale would read positively to the half-way line and then negatively. Even number scales only can be perfectly cyclic. Complete cyclic scales are

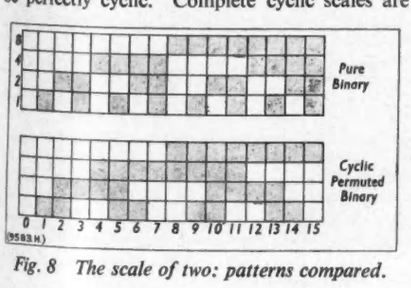


Fig. 8 The scale of two: patterns compared.

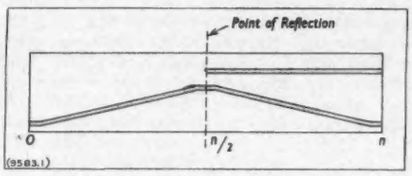


Fig. 9 Balanced cyclic scales.

continuous, that is, the end can be joined up to the beginning without ambiguity, since there is only this one digit difference at the two ends. A balanced cyclic scale is represented in Fig. 9.

Reflected scales are made up of major and minor cycles. These cycles are apparent in the CPB scale of Fig. 8, if we take the dividing lines through at 3/4, 7/8, 15/16, etc. In binary coded decimal scales reflections occur every ten divisions and sometimes also at five, as in the Watts reflected decimal (WRD) arrangement (these are called bi-binary). In either case the odd decades appear one way and the even decades the other, so that it is only by reference to the higher decades that the number can be translated. This is the main disadvantage of the system. Since, however, there is no need to duplicate the detectors the digitisers are as compact and economical as they can be.

While cyclic scales are non-arithmetic as they stand; that is, the individual tracks cannot be given any particular values, they are usually derived from arithmetic scales. For example, the WRD is derived from the 1, 2, 4, 2 scale of Fig. 10, and it is not difficult to get back to this scale. In the same way it is not difficult to revert to pure binary from CPB, and so on.

Whether the scale is cyclic or straight the choice of binary coded decimal patterns has in the past been a matter of personal preference and it is interesting to review briefly the more popular ones, mentioning the reasons for them. They are tabled in Fig.10.

The 1, 2, 4, 8 system is popular in choosing systems, since it is the usual code for computer inputs. The 1, 2, 4, 7 and 1, 2, 3, 6 systems have the advantage that not more than two 1's are used to represent any figure from 0 to 9. If

Dec.	1,2,4,8	1,2,4,7	1,2,3,6	Excess 3	1,2,4,5	1,2,4,2	WRD
0	0000	0000	0000	0011	0000	0000	0000
1	0001	0001	0001	0100	0001	0001	0001
2	0010	0010	0010	0101	0010	0010	0011
3	0011	0011	0100	0110	0011	0011	0010
4	0100	0100	0101	0111	0100	0100	0110
5	0101	0101	0110	1000	1000	1011	1110
6	0110	0110	1000	1001	1001	1100	1010
7	0111	1000	1001	1010	1010	1101	1011
8	1000	1001	1010	1011	1011	1110	1001
9	1001	1010	1100	1100	1100	1111	1000

Fig. 10 Binary coded decimal scale arrangements.

more than two 1's are received a fault has occurred. The excess 3 system is sometimes chosen because the addition or subtraction of two such numbers produce carries in the right place, making these operations easier to perform. Note that the code is so called because it is the pure binary number with 3 (011) added. 1, 2, 4, 5 systems are useful in choosing systems where an indication by one digit of more or less than 5 is required. The 1, 2, 4, 2 system is easy to translate electronically, and converts easily to and from the cyclic arrangement (WRD).

There are other arrangements with their own peculiar features, such as the Two-out-of-Five code, where five tracks instead of four are used and each decimal figure is expressed by two 1's and there are corruptions of the ones mentioned where extra 1's have been inserted, particularly at zero so that no figure is ever without a 1.

So far we have been concerned with the scales of two and ten and we have seen that there are only two forms of the scale of two and quite a variety of the coded decimal. It will be appreciated that with four binary digits it is possible to have sixteen different combinations and that in a decimal arrangement six of these are omitted.

Sometimes four binary digits are used to span 12 divisions to represent hours in a time system, or 14 to represent lb and 16 (CPB) for ounces in a weighing system. In a single change system it is not always possible to take part of an existing scale and chop it off to length, since the extreme ends may differ by more than one digit and in a continuous system this would be drastic. It is better to produce a scale with the correct span for the purpose, reflected mid-way, if it is a non-arithmetic type. An example is shown in Fig. 11.

In describing the codes it has been convenient to talk in terms of uniformly divided scales, but scales may not necessarily be uniform. It might, for instance, be desirable to make a scale

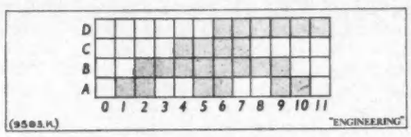


Fig. 11 Time scales representing 12 hours.

conform to the non-linearities of a thermocouple or to represent some trigonometrical function such as sine or tangent or perhaps squares or square roots for volumetric measurements. All the arguments used so far remain the same if one considers these as basically uniformly divided scales compressed in places and expanded at others, so that only the rates of change are affected. There must, however, be no omissions of figures or the single change rule will be broken.

APPLICATIONS

All the arrangements described have been made at some time or other and are all quite reasonable propositions. Some are in more general use than others and are likely to win the day over the more fanciful varieties. The reason is mainly economic, encouraged by the fact that most modern computers can be programmed to receive almost any code combination. The decision is therefore largely left to the manufacturer.

In this country the main uses for these scales have been inside potentiometric recorders or similar types of servo devices to digitise various process measurements such as temperature, pressure and so on. It will be appreciated that many of these measurements have non-linear characteristics and there may be one or many measuring points to cater for. These may all have the same characteristics or they may all be different. The transducers will generally produce a voltage or a pneumatic pressure indication of these physical quantities, which can then be transformed to mechanical motions. If linearising can be introduced in the transforming device the digitiser (which is driven from the mechanical motion) can carry a standard linear function scale. The alternatives are either to manufacture coded scales to match the functions they represent (which may not be economical) or to programme the computer to correct for the discrepancies.

Digitisers have also been used to a large extent by attachment to optical measuring equipment to represent linear measurements of coordinate tables for star positioning, map making, and so on. High precision types have been used for radar aerial position indication and lower resolutions for sugar polarimeters and a variety of special applications too numerous to mention.

By far the greatest use of digital scales has been in data recording, rather than automatic control, and although more use will be made of these in automatic process control now that optical digitisers are becoming available, it will be some time before the balance is reversed.

Human Element

How Much Noise in Inner London?

Two vans lent by the Building Research Station of the Department of Scientific and Industrial Research have begun work in the survey of noise in a 36 square mile area of London.

The survey is being carried out by the London County Council and the DSIR. Supplementary surveys of sound levels in selected areas are to be made in another vehicle and with separate equipment by the LCC's scientific adviser. Noise levels at various heights inside and outside tall buildings will be measured and special consideration will also be given to the effect of traffic noise on sensitive buildings such as hospitals, theatres and churches.

The area for the main survey is bounded by the boroughs of Wandsworth, Fulham, Kensington, Paddington, Hampstead, St. Pancras, Islington, Hackney, Poplar, Greenwich, Deptford, Camberwell, and Lambeth. Noise measurements on each site used in the inquiry will be taken for about two minutes in each hour over a twenty four hour spell. The recorded tapes will be analysed in the Building Research station laboratory.

Mr. N. Fleming, recently the head of the acoustics section of the National Physical Laboratory has been appointed consultant for the survey.

Call for Closed Shop in the Post Office

One of the first agendas for the trade union annual conferences to be published is that of the 167,000 member Union of Post Office Workers. It contains demands for a closed shop—so far the union is able to claim that 82 per cent of eligible post office workers are members.

Two of the union's branches would like to see the Post Office granting benefits obtained by union negotiations only to members of the union. There is a link between this and the union's request, turned down by the Postmaster General, for union subscriptions to be deducted from pay packets. This request had been made once before and rejected, in 1957. The union feels that it would be reasonable for the Post Office to deduct union subscriptions from the wage packet as similar deductions are already made for other organisations such as sporting clubs, insurance companies and voluntary health societies.

In the Post Office reply, it is pointed out that no other Civil Service union is making this request and that agreement might affect others in the Civil Service and outside.

There are two points here that must make the authorities extremely wary on this particular ground. The Union of Post Office Workers is affiliated to the Labour Party, pays its political contribution and therefore it could be said that a Government department in collecting union subscriptions was gathering political dues. The second point is that employers, however happily they get along with the unions and their representatives, would hardly welcome another addition to their clerical overheads, and particularly not this one.

Misha Black made Consultant to Beagle

Professor Misha Black, the distinguished industrial designer, is one of two consultants appointed by Pressed Steel's BEAGLE group (British Executive and General Aviation).

As consultant in industrial design to the group, Professor Black has already started work on Beagle aircraft. As a senior partner in the Design Research Unit, BEAGLE's new consultant was one of those responsible for interior designs on the new liner Oriana.

This latest appointment will mean that Misha Black has designed for sea, air and land transport, for he was one of the team of consultant designers to the British Transport Commission for the bodywork of diesel and electric locomotives. A Royal Designer for Industry, Misha Black is the first Professor of Industrial Design at the Royal College of Art.

The other consultant is Professor Alec D. Young, who holds the chair of aeronautical engineering at Queen Mary College, London. He becomes consultant in aerodynamics to the group. A. D. Young went from Cambridge to the aerodynamics department of the Royal Aircraft Establishment, Farnborough, in 1936. Eleven years later he went to the College of Aeronautics, Cranfield, as deputy head of the aerodynamics department and senior lecturer. Appointed Professor of Aerodynamics in 1950, he left in 1954 to join Queen Mary College.

In two other appointments BEAGLE have named their technical director and deputy chief designer. The technical director, BEAGLE-Auster Aircraft, will be Mr. Marcus Langley, a director of Tiltman Langley. First trained as a naval architect, Marcus Langley joined Short Brothers at Rochester when he was 21 to work on hull design for their first metal flying boat, the F5. From 1929 to 1935 he was concerned with aircraft design for Handley Page, Desoutter Aircraft and de Havilland. He then became chief designer of the British Aircraft Manufacturing Company.

At the end of the Second World War he formed, with Mr. Hessell Tiltman, the partnership which is now named Tiltman Langley Limited.

The deputy chief designer is Mr. T. D. R. Carroll, once a student of the Airspeed Aeronautical College and a member of the Pathfinder Force in Bomber Command.

After post-war experience with Fairey Aviation and with BOAC, T. D. R. Carroll went to Bristol Aircraft as deputy design manager, and was responsible for all Canadian and American design variations of the Britannias.

Warranty Clauses Deleted by Buyer

The battle over manufacturers' guarantees that are not always perhaps quite equal to the customers rights under the common law continues. The most recent incident concerned a woman who bought a Morris Minor car. Mr. D. R. V. Vickers, secretary of the British Standards Institution's Consumer Advisory Council, has described how, on the Council's advice, the customer returned the Morris warranty after having deleted certain clauses which she did not feel able to accept.

She had received a reply accepting the deletion of the clauses and observing that the company had received " numerous objections " of a similar kind.

In the unaltered form of the warranty the company would have been freed from liability for " personal injuries or consequential or resulting liability, damage or loss arising from defects." The company's decision would also have been final in all claims, regardless of liabilities implied by common law, statute or otherwise.

Three Times Sunk and Still No Replacement

However well made the equipment it is reasonable for the manufacturer to expect replacement orders from time to time, even if he does have to be very, very patient.

For Laurence, Scott and Electromotors, who specialise in electrical machinery and control gear, there has recently arrived from the Mediterranean some spectacular proof of the long-lasting nature of their equipment, but no sign of a replacement order.

Twenty-five years ago the company supplied an electric trawl winch for the French trawler Mercedita. This vessel is now in Greek hands and the new owners have written to ask for a wiring diagram.

Nothing odd about that? Perhaps not, but Laurence Scott have also learned that during the war the Mercedita was three times sunk. The owners point out in their letter that, " the equipment is all in very good condition."

After all this the makers receive only a request for a wiring diagram, and presumably a pleasant filip to their self-esteem.

With the wiring diagram is being sent a copy of the company's Instructions for Drying-out Electrical Equipment, which in a boat with the history of the Mercedita might seem worth keeping in a safe place.

The Electricals Honour Lord Nelson

Lord Nelson of Stafford, the English Electric company's chairman, has been made an Honorary Member of the Institution of Electrical Engineers. The election was " in recognition of his outstanding contribution to the development of electrical science and engineering, and for his many services to the Institution."

A diplomatist at the City and Guilds Technical College before he was 18, George Horatio Nelson developed the ability of reaching positions at a much earlier age than usual. At a time when experience was synonymous with mature age, in engineering as in many other professions, he was Chief Outside Engineer at 22 for the Brush Electrical Engineering company, whom he joined at Loughborough as a postgraduate Brush student.

Joining British Westinghouse, which became Metropolitan Vickers Electrical, by 1920 he had established and become manager of their Sheffield factory.

Lord Nelson was made a Peer last year, thirty years after joining English Electric as managing director in 1930. An associate member of the Institution of Electrical Engineers since 1912 and a member since 1918, he was President in 1955, two years before becoming President of the Institution of Mechanical Engineers.

Faraday Medal for MIT President

Dr. Julius Stratton, President of the Massachusetts Institute of Technology, has been awarded the Faraday Medal of the Institution of Electrical Engineers, for notable contributions to technological education and radio communication research.

Dr. Stratton's most notable work has been in the theory of transmission line, waveguide and antenna systems in the wartime development of centimetre wave radar. At MIT he has inspired the move towards a revision of the engineering undergraduate course, involving a considerable strengthening of the scientific foundations and the inclusion of the humanities in the syllabus.

An assistant professor of electrical engineering at MIT back in 1928, Dr. Stratton moved through successive positions to become director of the electronics research laboratory from 1945 to 1959. After serving as Chancellor of the Institute from 1956 to 1959, and acting President for two years from 1957, Dr. Stratton was appointed President of MIT in 1959.

CERN Physicists Studying in Russia

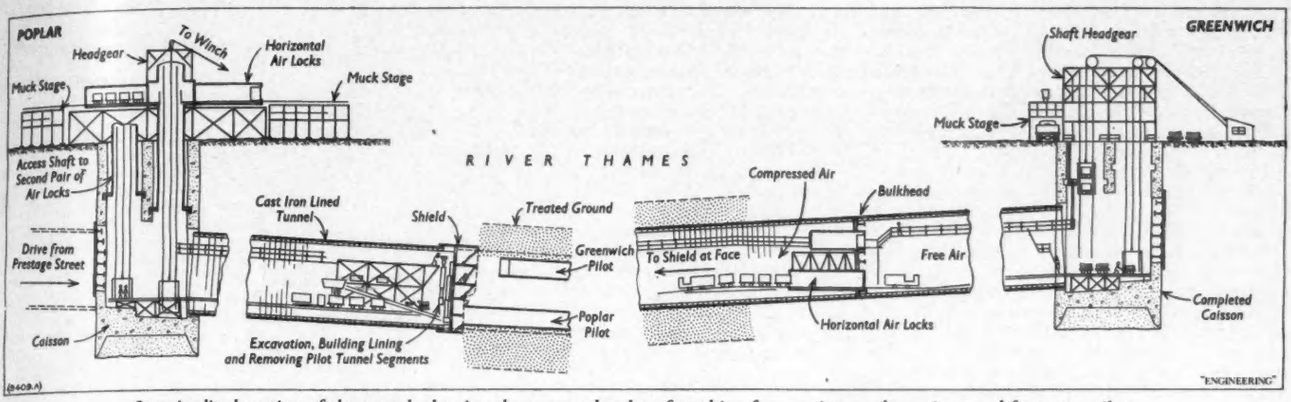
The first physicists from the European Organisation for Nuclear Research (CERN) to do basic nuclear research for a period of several months in Russia have travelled from Geneva to the Soviet laboratories at Dubna, north of Moscow. The facilities there are organised in a scheme for cooperation between member states after the fashion of CERN in Switzerland.

The three scientists are Dr. W. H. Cottingham, who joined CERN from Birmingham, Dr. E. Fischer, from Germany and Dr. M. Schneeberger, from Switzerland. Under an agreement reached in 1960 between CERN and Dubna, three Russian physicists worked in Switzerland last year and two others arrived this January.

Change at the Top for Churchill Machine Tool

Associated British Machine Tool Makers have announced that following the purchase by the Birmingham Small Arms Company of the entire capital of the Churchill Machine Tool Company, Sir Greville Maginness has resigned his position as chairman of Churchill and also from Associated British Machine Tool Makers.

Mr. Edward Parkinson has resigned from the board of Associated British Machine Tool Makers for personal and private reasons, and Mr. J. W. Butler has been elected chairman of the company.



Longitudinal section of the tunnel, showing the proposed order of working for opening up the main tunnel from two pilots.

Driving a Tunnel Just Under a River

Duplication of the Blackwall Tunnel under the River Thames involves driving a tunnel 2,844 ft long, 800 ft through water-bearing gravel fill. Pretreatment of the ground will make it possible to open up the main tunnel from pilots.

AN IMPORTANT part of the London County Council's road improvement schemes is the duplication of the Blackwall Tunnel which, for many years, has been a principal crossing of the lower Thames. Ever increasing traffic has made the existing tunnel inadequate and a new vehicle tunnel is being driven adjacent to the old. When completed, all southbound traffic will go through the new tunnel and the existing tunnel will be restricted to that going north. In conjunction with the tunnel project, improvements have been made to the approaches and the road works on the north side of the river have already been described (ENGNG., vol. 189, '59, p. 803).

The contract for the tunnel was let nearly a year ago to Balfour, Beatty and Company Limited of London and involves constructing a tunnel 2,844 ft long, to be lined in cast iron segments having an inside diameter of 28 ft 2 in. For a short length on both sides of the river the tunnel will be in the blue London clay, but for the greater part it will have to be driven through water-bearing gravel fill, about 800 ft of the tunnel being under the river. This section will be chemically treated to increase the impermeability. The cover over the top of the tunnel at the centre of the river is only 18 ft. A total of 100,000 cu. yd of spoil have to be excavated and the weight of cast iron lining segments to be erected is 24,000 tons. The contract period is 3½ years. The work being done under the direction of Mr. J. Rawlinson, C.B.E., M.I.C.E., chief engineer to the County Council, and the consulting engineers for the contract are Mott, Hay and Anderson, 9 Iddesleigh House, London, SW1.

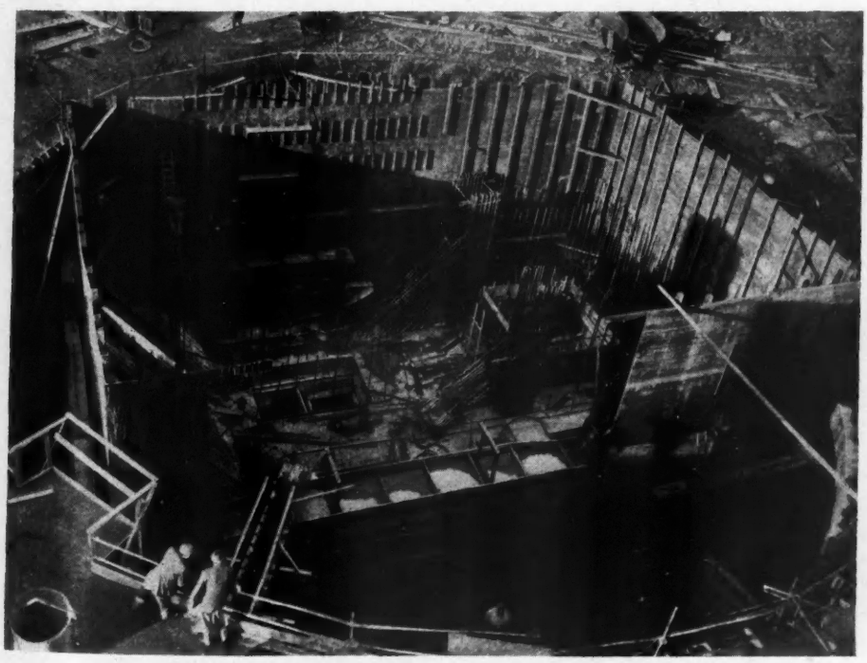
TWO PHASES

The contract is to be carried out in two phases. The first phase has involved sinking a shaft on each side of the river, and shield driving in compressed air two pilot tunnels 7 ft in diameter is now in progress. In the central gravel bed below the river the pilots overlap each other, one above the other, partly to obtain a double impression of the ground to be worked when opening up the main tunnel, but principally to provide the means of obtaining the injected ring of treated ground, as shown in the cross-section on the following page. Simultaneously a caisson is being sunk on each side of the river from which the second phase will be started.

The second phase will consist of driving the full size cast iron lined tunnel from the caisson on each side of the river. The choice of cast iron segments for the work, rather than reinforced concrete, was dictated by the size of the tunnel and the severe conditions under which they will have to serve.

The position at the moment is that the pilot tunnels are being driven; the caissons are being constructed and two main shields are being assembled nearby ready for the commencement of phase two. Injection is expected to begin in early summer.

The caissons are each 60 ft by 40 ft in plan and will be 80 ft deep. To ease their construction, steel sheet pile cofferdams of 80 ft diameter and about 30 ft deep have been constructed in the gravel, and the caissons are being built inside the cofferdams, as shown in the photograph on this page. The shoes of the caissons are of reinforced concrete with an outer steel skin and the caissons are being sunk by excavation from below, allowing them to settle under their own weight. Provision has been made for sinking the caissons under compressed air.



Constructing a rectangular caisson within the protecting ring of a sheet steel cofferdam.

CHEMICAL CONSOLIDATION

The purpose of this impermeable ring is threefold:

(1) To control the inflow of water over the lower portion of the tunnel where, during driving, the hydrostatic pressure will appreciably exceed the air pressure.
(2) To reduce air loss to a minimum, and to prevent the development of "air piping" at the crown, where the minimum depth of strata is as little as 18 ft.
(3) To provide a degree of consolidation at the crown to facilitate the subsequent excavation.

To meet the above requirements, a treated annulus—11 ft thick over the upper half of the profile and increasing uniformly to 15 ft thickness at the invert, as shown in the diagram—will be formed by the systematic injection of selected clay cement and chemically-conditioned bentonitic clay grouts. In the case of the upper portion of the tunnel, it will be supplemented by a central layer injected with TDM chemical grout—a grout which has the ability to give highly consistent impermeability.

The TDM process is a development of the Cementation Company Limited who, as nominated specialist sub-contractors, have been given the ground treatment contract. The process involves the injection of TDM as a single-shot process whereby three solutions are pre-mixed and injected as one. Gelling is controlled and occurs only after the solution has permeated to the desired area.

Since it is impracticable for the injection

to be undertaken from the river, the work has been so planned that application of the treatment will be made from within the two pilot tunnels. Ball-jointed glands will be fitted in pre-formed holes in the cast iron linings of the pilot tubes and, through these, special injection rods will be driven at various angles through the strata to allow injection of the grouts.

Preparation of the grouts will take place on surface, whence they will be pumped through ranges installed within each of the pilot tunnels to mixing tanks before injection.

Before, and on completion of treatment, purpose-made testing equipment will be used to determine the overall permeabilities of the untreated and treated strata and to ensure that an overall permeability equivalent to three-quarters of a gallon of water per minute per ft of main tunnel has been created within the annulus.

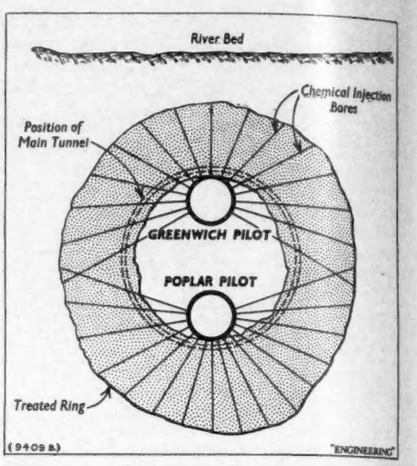
In all, some 35,000 cu. yd of sands and gravels will be injected, entailing the use of about 900 tons of clay and 25,000 gallons of TDM. The treatment, which will be carried out on a shift basis, will take some 28 weeks to complete.

Opening up the main tunnel is expected to start about the end of this year, driving riverwards from the two caissons. (The connections to the new approach ramps are to be built under separate contracts.) As the longitudinal section shows, the work will proceed under compressed air. Excavation will be by hand—the work will necessarily be very wet—and a short high lift conveyor belt will probably be fitted up to assist loading away of the spoil. Spoil removal will be by 30 cu. ft skips running on four narrow gauge tracks and drawn by battery locomotives. The choice of skip and track, as opposed to the use of conveyor belts only or the use of trackless equipment, was based on the proved reliability and adaptability of the method.

Two low pressure compressed air stations have been set up, one on each side of the river to serve the independent sections of the work. Each station is able to deliver to a working face 15,000 cu. ft of free air per minute from three electrically driven compressors, each of 5,000 cu. ft per minute capacity. In addition, as a standby in the case of electrical power failures, there are five diesel-driven compressors, each of 1,000 cu. ft per minute capacity, installed in each station.

LABOUR FORCE

Work is proceeding in three continuous eight-hour shifts and, at the present, the total labour force is between 180 and 200. It is expected that this figure will remain fairly constant throughout the period of the contract, though a peak force may build up to 250 when driving the main tunnel is in full progress. An up-to-date medical centre has been established on the Poplar side, with X-ray equipment and two medical airlocks for treating attacks of the "bends," under the supervision of a resident doctor. In addition, a casualty station with two more medical air locks, in the charge of medical orderlies, has been equipped on the Greenwich side.



Cross-section through the tunnel workings, showing the annulus of treated ground that will be obtained by injection from the pilot tunnels.

Cut-Off Trenches Made Cheaper and Quicker

A new system of spoil removal in the excavation of cut-off trenches for reservoirs has resulted in an output of 80 cu. yd per man shift, compared with a previous output of rarely more than 1 cu. yd. The amount of plant required is also reduced. Packed with impervious clay, these trenches seal the perimeter of reservoirs and prevent seepage.

The orthodox method of excavating cut-off trenches, which may be 100 ft or more deep and 6 ft wide, has proved to be expensive and even dangerous. Sometimes more than 100 men have had to be employed to dig trenches from ground level by hand, using several large jib cranes, with hoppers which have had to be manually filled and emptied.

A new approach to the problem has been made in recent months by Mr. C. J. MacLeod, contracts manager of Thyssen Shaft Sinking Company Limited, on the site of the Staunton Harold Reservoir, near Melbourne, Derbyshire. The excavation of the trench has been undertaken by Thyssens on behalf of Tarmac Civil Engineering Limited, who are constructing the reservoir for the River Dove Water Board, Leicestershire.

The first improvement in the method of excavation was the replacement of manual labour by a Joy-Sullivan N 221 double-drum slusher using a scraper bucket which was specially designed for the job.

The first stage of the operation was to sink shaft midway along the site of the trench, to a depth of about 10 ft in excess of the final trench depth. In plan the shaft was 6 ft (the width of the trench) by 15 ft long. The larger dimension allowed for two bays for the positioning of the Joy-Sullivan slusher haulage equipment and a central bay for spoil raising by crane and skips. The shaft was timbered and the slusher scraped spoil into the central bay of the shaft.

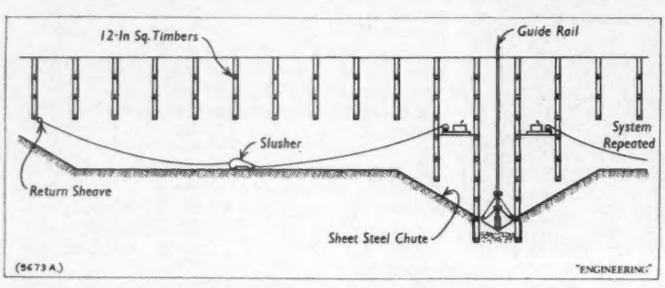
Slushing had to be stopped periodically to timber the sides of the trench and to lower the haulage equipment to follow the level of the trench floor. The output of the slushers was, however, restricted by the speed of removal and disposal of the spoil. Thyssens have now overcome this problem after consultation with Michael and Partners Limited of Chesterfield and John Smith of Rodley Limited.

It was decided that the most promising development would be the substitution of a grab for the skips. The grab would have to be a good digger and capable of close guidance to a considerable depth. Michael and Partners adapted one of their standard 21/17 cu. ft capacity self-trimming grabs for the purpose. This grab is essentially a digging grab. Because of the receding radius of its jaws, the grab tends to pull itself into the stock so that it digs throughout the closing stroke and lifts a full load every time.

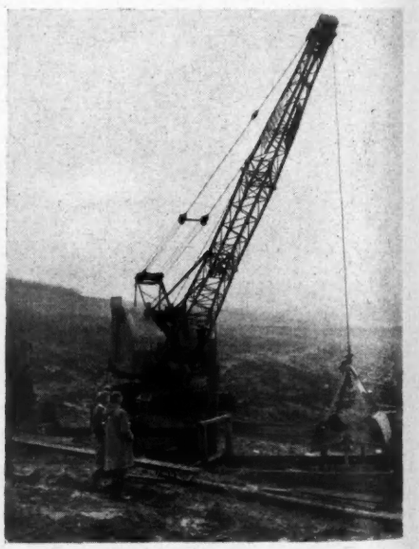
A spring-loaded guide system was designed and built into the grab which could then be operated firmly with a lateral variation of 6 in between guide rails. The guide shoes, made in high carbon steel, were given a self-feeding profile. Using this grab with a double drum Smith 21 excavator (made by John Smith of Rodley) it is no longer necessary to sink a deep shaft at the centre of the proposed excavations. The method of operation now consists simply of excavating a central sinking bay to a sufficient depth to contain the slusher haulage equipment mounted above a sheet steel chute and to proceed from there.

With guide rails fitted to the timbered sides of the sinking bay the grab can be dropped straight down to bite into the spoil gathered by the slusher. The combined self-trimming and digging characteristics of the grab enable it to deepen the sinking bay progressively as the trench becomes deeper. These features of the grab result in a well squared-off shaft.

Only 10 per cent of the excavation is manual. This is devoted to hand-dressing the sides of the trench, timbering and lowering the slusher haulage and sheet steel chute. The labour force on this part of the work at the reservoir has been reduced from 114 men, using eight cranes and eight hoppers, to the two men who operate the crane and the slusher and a third man who controls the grab.



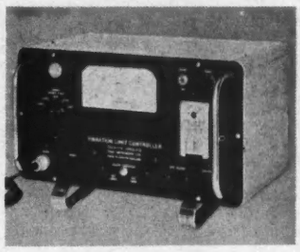
Longitudinal section of the cut-off trench shows the method of excavation using a Joy-Sullivan N 221 slusher and an adapted Michael and Partners self-trimming grab.



The grab being lowered into the sinking bay by the Smith 21 excavator. The guide rails and spring load self-feeding guide shoes simplify locating the grab.

VIBRATION LIMITER

For Machines and Structures



THE VIBRATION limit controller, type 1434, is designed to monitor, record and measure vibration in machines and structures.

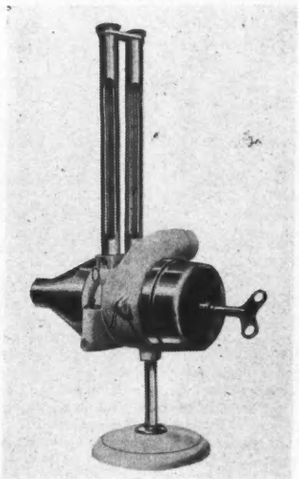
Facilities are incorporated for operating an alarm or for shutting down the machine if the vibrations become excessive. A direct reading meter is incorporated to show the actual vibration level and an output signal is provided for connection to a standard recording dc milliameter for providing a permanent continuous recording. The pick-up is hermetically sealed in inert gas and can be attached to the machine at a considerable distance from the control unit.

The output signal is compared with a preset bias level and fed to a trip valve with a heavy duty relay in the anode circuit. The bias can be adjusted to trigger the valve at any level between 20 and 100 per cent. To avoid unnecessary operation a delay timer is incorporated which requires the excess vibration to last for more than 7 seconds at 5 per cent above alarm level, or for 3 seconds at 20 per cent excess vibration, before the alarm is operated.

Four sensitivity ranges are provided from 0·001 in to 0·030 in; metric calibration is also available. The frequency range is from 20 to 400 c/s, corresponding to 1,200 to 24,000 rpm, and the contacts are rated at 5A ac 250V non-inductive. The unit will operate from standard mains supplies of 110V or 200-250V 50 to 60 cycles, the consumption being approximately 40 W. The control unit measures 10 in by 14 in by 9 in high and weighs 24 lb. *Dawe Instruments Limited, Harlequin Avenue, Great West Road, Brentford, Middlesex.*

UNIVERSAL PSYCHROMETER

Motor Driven



THE THIES psychrometer now available in this country is a high precision instrument working on the Assman principle.

Humidity measurements can be made either in the open or in tunnels and pipe lines by connecting up with tubing. A fan, driven either by clockwork or by an electric motor, draws the air in over the bulbs from the side remote from the operator so that the reading is not affected by the human presence. Air velocities of more than 2 metres per second are obtained. The clockwork motor will drive the fan for a period of about 10 minutes continuously on one winding.

The two thermometers are calibrated in $\frac{1}{5}$° C divisions and give a range of measurement from − 10° C to + 50° C. Other ranges are available to order. Supplied with the instrument are exchangeable connecting pieces, automatic moistening device, and psychrometric chart. In addition there is a container for holding samples for determining the humidity of powdered materials. The complete instrument weights approximately 11½ lb. *British Sarozal Limited, 22 Berners Street, London, W1.*

UNIVERSAL METER

Includes Phase and Frequency

THE GOSSEN universal meter Uphi will measure current, voltage, power factor, frequency and resistance.

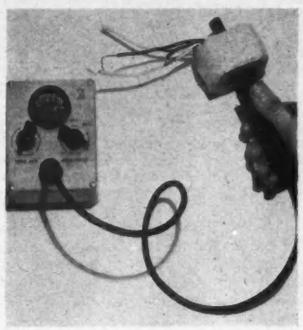
There are six voltage ranges from 12 to 600 V ac with internal resistances from 200 to 10,000 ohms per volt. Ten current ranges go from 0·06 A to 120 A with voltage drops of 80 to 20 mV according to range. Cos ϕ and sine ϕ can be measured within all voltage and current ranges from − 90° to + 90° to give the reactive components.

Frequency has two ranges covering 40 to 4,000 c/s. There are three resistance ranges up to 100 kilohms. Power for resistance measurements is obtained from a 1·5 volt battery contained in the instrument which is approximately 10 in by 5 in by 4½ in, and weighs 5½ lb.

Currents are measured by an internal transformer connected in cascade; voltage is applied via an internal potential transformer and full wave rectifier, and a further rectifier circuit forms the vector sum and difference of current and voltage for cos ϕ and sine ϕ readings. Inductive reactances are used for frequency indication. *Aveley Electric Limited, Ayron Road, Aveley Industrial Estate, South Ockendon, Essex.*

DETECTOR

For Shorted Turns in Coils



THE illustration shows a portable instrument for the detection of shorted turns in coils.

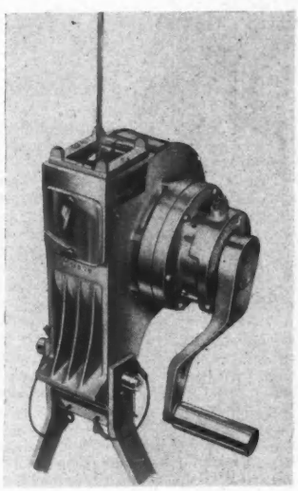
The Mark I instrument is compact and versatile. It will give a positive indication on the meter of the presence of one or more shorted turns in a coil and is therefore useful in checking transformers, chokes and solenoids. The test is made by simply inserting a probe into the coil; no connections to the windings are required and the instrument is therefore suitable for quantity production.

A small oscillator unit is contained in a metal case measuring 4¾ in by 3¾ in by 2¾ in. The circuits are transistor driven. On the front is the indicating meter and the two controls, one for setting the zero and the other for adjusting the sensitivity. Power for the operation is supplied by a standard 4·5 V battery contained in the case.

One of the three hand probes is plugged into the socket in the case, the choice of probe depending on the size of the coil under test. The three work at different frequencies to give the optimum performance over a wide range of coil sizes. The largest has an overall length of 9¾ in with a handle diameter of 1·2 in and probe diameter of 1 in. The middle size measures 7·4 in long with handle of 1·2 in and probe of 0·5 in diameter. The third and smallest has an overall length 4½ in, the handle and probe diameters being 0·5 in and 0·2 in respectively. *Spembly Limited, New Road Avenue, Chatham, Kent.*

CRADLE WINCH

High Lifting Rate



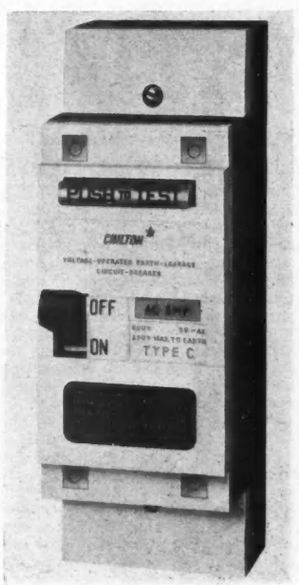
IT IS claimed for the Strateline cradle winch that the design and construction give high lifting rates of 12 to 14 ft per minute with small manual effort.

The winch has an overall weight of 39 lb and has a single point pivot fixing for attaching the cradle. A special mechanism is incorporated to allow quick run-off and rewind of the cable during fitting up. The cable normally supplied is 110 ft of ¾ in, 6 by 19 galvanised strands of preformed plough steel of 110-120 tons tensile strength, tested to 5,150 lb. Ball and roller bearings are used throughout and hypocycloidal reduction gearing. The mechanism is self-acting and self-sustaining, eliminating the manual operation of pawls and levers.

The whole mechanism is totally enclosed and grease packed for protection against rust and dust. The case is made from heat treated aluminium alloy and the gears and shafts from high tensile steel. The bronze cable aperture is designed to prevent build up of cable at the drum flanges and to provide a smooth face for the cable. *Scaffolding (Great Britain) Limited, Building Equipment Division, Mitcham, Surrey.*

EARTH LEAKAGE CIRCUIT BREAKER

Voltage Operated



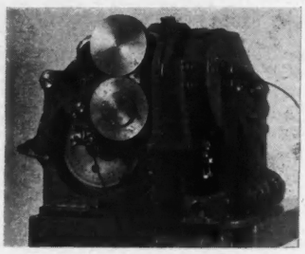
THE EARTH leakage circuit breaker illustrated is designed particularly for the rural and remotely-situated consumer.

The use of a voltage operated device is becoming more important as the use of non-metallic water pipes, which have so frequently been used in the past as earth connections, spreads. The type C breaker is made with ratings of 60A or 100A for a maximum voltage of 500 ac (250V ac to earth). The breaker is designed to trip at leakage currents of 30 to 35mA under all conditions. A spark gap for lightning protection is included.

The operating mechanism is sealed in a tamper-proof case of urea and phenolic mouldings, which is dust proof. The direction of wiring can be either from top to bottom or from bottom to top as desired; the entries are dust sealed with rubber mouldings. A test bar is provided to check the operation. The breakers comply with BS 842 (1939). *Chilton Electric Products Limited, Hungerford, Berkshire.*

WIRE STRIPPER

Cuts and Twists



SINGLE CORE wires with outside diameters up to 0·16 in can be stripped and cut to length in the Luma machine now available in this country.

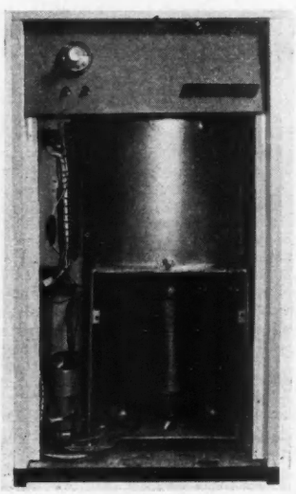
The machine is designed for plastic insulated wires which it will strip of insulation, cut to length and twist the strands at both ends. There is a choice of 15 different cutting lengths from 2 in to 5 ft or from 4 in to 9 ft 10 in, and there is an attachment to increase the range to cover from 11½ in to 30 ft.

The wire is fed between rolls which are engaged or disengaged by two pins adjustable for the feed length. Cutting and stripping are carried out by a rotating head driven by a braked ring. Each of the two cutting tools is equipped with a central knife for cutting and two side knives for stripping. A collet stretches the wire backwards and a gripper pulls it forwards while the head is rotated, so that the ends of the strands are twisted together while they are being stripped.

Wire ends can be stripped back for a distance from 0·3 to 0·4 in. For lengths up to 5 ft production is up to 1,500 lengths per hour; lengths up to 30 ft can be cut at 240 per hour. Power is supplied by a ¼ hp squirrel cage motor running at 1,000 rpm. The machine measures 1 ft 2 in long by 1 ft 4 in wide and 11 in high; it weighs 88 lb. The standard model is intended for bench mounting but it can also be fitted on a castor mounted stand. Another accessory is a counter for controlling the number of wires cut. It is claimed that the machine is economical for use even for small quantities. *Vicsteels Limited, Craven House, 16 Northumberland Avenue, London, WC2.*

OIL FIRED BOILER

Vaporising Type



ONE of a new range of six oil-fired boilers is the vaporising model shown in the illustration.

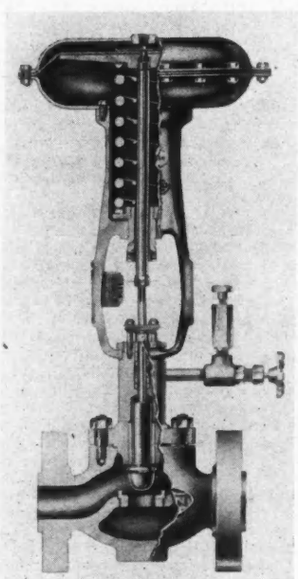
Two of the six are vaporising types with outputs of 40,000 Btu and 48,000 Btu per hour. The remaining four are pressure jet models with outputs up to 160,000 Btu per hour. The on-off system of control is used. Relighting is by electric glow plugs, the control box being within the main boiler casing.

A short drum burner is used in the vaporising models with the KBA oil control. The oil inlet control valve has a positive shut-off and in conjunction with a heat sensing switch positioned near the combustion door, provides a fire safety cut-out. A down-draught diverter and flue break are fitted internally within the boiler casing. The burner has adjustable legs to facilitate levelling.

Both units are 36 in high to conform to standard kitchen units, and 21 in deep. The smaller is 21 in wide and the larger 24 in. The casing can be locked for safety and cleaning is only needed once or twice a year. *Henry Wilson and Company Limited, PO Box 6, Kirkby, Liverpool.*

CONTROL VALVE

Range of Seatings



NEW INTRODUCTIONS have been made with the Masoneilan heavy duty control valves in the 20,000 series.

These are single seat valves with globe bodies and a wide range of applications. Extra heavy top guiding of the plug eliminates the need for bottom guiding and reduces turbulance. Coupled with the port design this arrangement allows a greater flow through a given seat diameter. The increased capacity is said to make the valves approximately equal to the equivalent line size double seat control valve. Greater out of balance pressure can be withstood across the seat while maintaining tight shut-off and stable throttle control. Standard bodies are carbon steel and trims stainless steel.

The valves can be fitted with a range of interchangeable reduced area plugs and seats. Sizes are from ¾ in to 2 in with screwed connections with trim sizes of ¼ in, ⅜, ½, ¾, 1½ in and 2 in. Flanged versions go up to 10 in pipe. *Crosby Valve and Engineering Company Limited, Ealing Road, Alperton, Wembley, Middlesex.*

DRYER

For Electrical Equipment

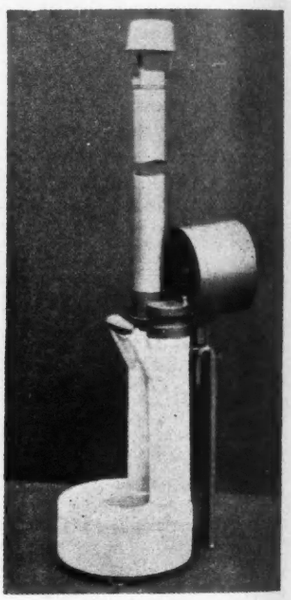
ELECTRICAL equipment can be dried out *in situ* by the E.A.F. unit now available in this country.

A typical use of the apparatus is on board ship where the ingress of moisture is a constant risk. The apparatus is essentially a source of low potential current for passing through the circuit whose insulation is faulty and needs drying out. The unit is fitted with an ammeter and voltmeter and there are also a megohmeter by which the insulation resistance can be constantly monitored, a resistance thermometer to indicate the temperature of the conductor and a thermostat to control the drying temperature and prevent overheating. On the top plate is a graph showing the relationship between current capacity of the conductor, the heating effect of the current and the life of the cable under various drying conditions of current overload.

The apparatus operates from a 220 volt 50-60 cycle supply and a converter is required for operation from dc mains. The output terminals cater for cable sizes from 3/036 to 7/052; voltage ranges are nominally labelled 2, 5, 10, 15, 20, 25, 30 and 60 volts, and a maximum output of 2 kVA is possible. The unit is compact, measuring only 15½ in by 15½ in by 21½ in. *A.E.I. Marine Department, Woolwich, London, SE18.*

IMMERSION WATER HEATER

Portable



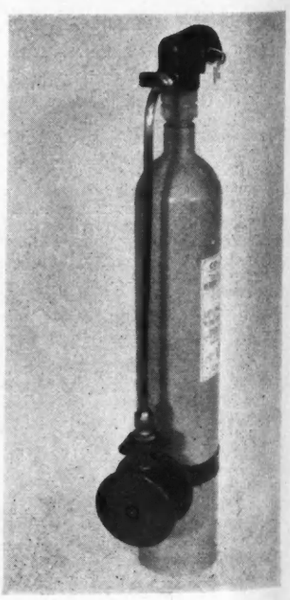
TANKS of water on sites can be heated by the Aqualeo portable oil fired immersion heater.

This device will burn petrol, paraffin, TVO, or gas oil. The lower horseshoe shaped portion is immersed in the tank and contains the flame from the burner. The output is approximately 50,000 Btu per hour. Fuel from the 1¼ gallon tank vaporises in the stainless steel burner, ignition being by wick. Consumption is ¼ gallon per hour.

The construction is steel with a heat resisting finish. Dimensions of the base are 15 in diameter and the overall height of the heating portion is 2 ft 11 in. Four lengths of stack pipe are supplied giving a height of 8 ft to the cowl. The net weight is 52 lb. On contractors' sites the unit can be used to warm water for concrete mixing, and on farms it can be used to thaw out drinking water. Space heating and drying-out are two other applications. *Lion Stamping Company Limited, 35 Marshgate Lane, London, E15.*

FIRE ALARM

Self-Powered



A POWERFUL alarm siren can be sounded by the Colarm unit.

The unit is normally designed to fix on the wall close to an exit and is taken down for use. It can be carried in one hand and switched on and off at the same time. Operation is by the trigger and in the 5 lb size the alarm will sound continuously for 1½ minutes without any external power supply. The Colarm can also be stood on the ground.

The power output is of the order of 100 to 120 decibels in the 1 to 3 kilocycle range, which is considerably louder than normal electric bells. The design is such that the unit will operate automatically if the ambient temperature should exceed 120° F but it is not intended as an automatic detector. Virtually no maintenance is required. Carbon dioxide is the operating medium and in addition to the 5 lb size already mentioned there is a larger size to hold 10 lb which will give a continuous alarm for 3 minutes. *The Walter Kidde Company Limited, Belvue Road, Northolt, Greenford, Middx.*

GEAR PUMPS

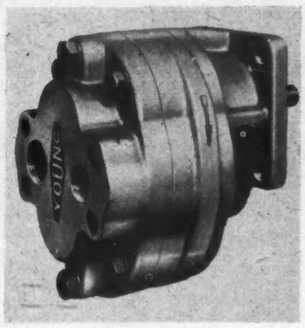
For Hydraulic Systems

A NEW range of hydraulic gear pumps covers capacities up to 30 gallons per minute.

The pumps are of the constant displacement type and are primarily intended for heavy duty applications involving either continuous or intermittent operation such as mechanical handling equipment, coalmining appliances, earth moving vehicles, and control systems.

There are four basic models in the range; each is available with either side or end ports. The capacities at 1,000 rpm are 12·5, 18, 24, and 30 gpm. A special feature is that the direction of rotation can be changed simply by inverting the end plate. A system of grooves formed in the end cover relieves the build-up of pressure due to the trapping of oil at the bottom of the gear teeth and eliminates pressure on the oil seals and joints.

The four cheek plates are relieved for balancing the gears laterally to avoid an uneven pressure loading on the gear



faces, reducing wear. The driving shaft is positioned by deep groove ball bearings so that no side thrust is imposed on the gear faces or cheek plates. The radial load of both shafts is taken by rigid needle roller bearings. The gears are machined from high duty alloy steel, case hardened and ground, and the bodies are available in high duty aluminium alloy or close grained cast iron. *Joseph Young and Sons Limited, Kay Street, Bolton, Lancashire.*

LIFTING TABLE

Hydraulic Operation

THE illustration shows a "Summit" lifting table arranged to supply a press.

The table is hydraulically operated and is simple in construction. All the working parts are enclosed yet only eight setscrews need be removed to enable maintenance work to be carried out. The tables are flanged to prevent warping and are fitted with welded wearing strips to facilitate cooling. The operating ram is of honed tube and the piston rod is chromium plated. The pressure feed is connected to the base of the table and one hydraulic pump unit will operate up to four tables.

A typical working height is 30½ in and the vertical lift that the table will give above this height is 21 in, that is giving an overall maximum height of 51½ in. Tables are normally supplied with sizes and lifts to suit individual requirements.

A feature is that the table can be stopped and started at any position during the lift; the return stroke is made

under gravity being effected by the weight of the table. The example in the illustration is shown in the lowered position. Other applications include installations for feed and transfer line work. *Sutcliffe Hydraulics Limited, Speedwell Works, Whitwood, Castleford, Yorkshire.*

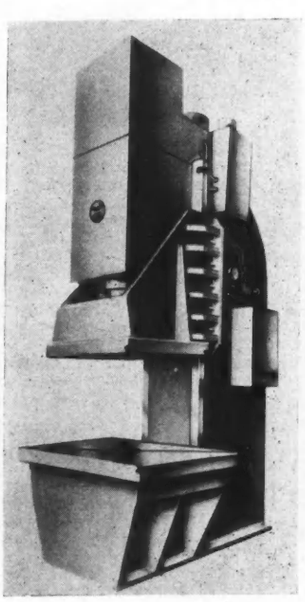
OPEN PRESS

250 tons Capacity

THE OMF-Ferralba delta type open gap press whcih has a capacity of 250 tons is now available in this country.

The press is of all steel construction and has hydraulic operation. The table surface is approximately 51 in by 40 in and the stroke is 39½ in. Operating speed is 15 strokes per minute. The hydraulic system is powered by a 15 hp motor direct coupled to a multi-piston pump. An automatic valve allows quick filling and discharging during idle strokes and also with the adjustable slide stopping device. Control is either by push buttons on the machine working through a servo or directly by a hand lever.

The full force is exerted over the entire stroke so vertical die adjustment is eliminated. Good accessibility is a feature and the provision of large surfaces for piston and slides gives high precision and reduces wear. An extra is a folding press brake attachment with a maximum length of 9 ft 10 in. *Rushworth and Company (Sowerby Bridge) Limited, Sowerby Bridge, Yorkshire.*



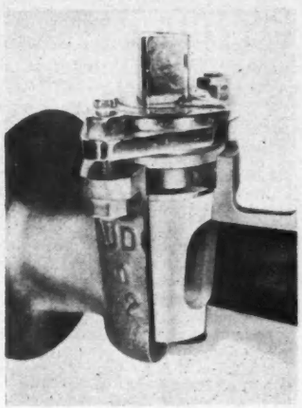
PLUG VALVE

Sleeved with Ptfe

A RECENT development in the Audco range of valves is the sleeving of the plug with ptfe.

The inertness of ptfe makes it possible for the valves to handle corrosive liquids and, in addition, the problem of metal to metal contact is eliminated with the consequent removal of sticking and galling. It is claimed further that the valves are leak proof and require very little turning effort to operate.

The sleeved valves are available in sizes from ¼ in to 4 in with the bodies made in stainless steel (either 18/8 or 18/10/3 alloys); in Audcolloy (an austenitic cast iron of the high nickel high silicon type); or in high duty cast iron. All three types are suitable for working pressures up to 150 lb per sq. in at temperatures up to 100° C. Those made of Audcolloy are particularly suitable for medium concentrations of sulphuric acid, strong caustic soda and hot fatty acids. They are more resistant to abrasion than the standard cast iron versions.



The spindle carries a port indicator showing whether the valve is opened or closed. A visible stop limits the rotation of the plug to 90°. Sealing is obtained by a gland with packing, packing ring and bearing gasket against the plug. *Audley Engineering Company Limited, Newport, Shropshire.*

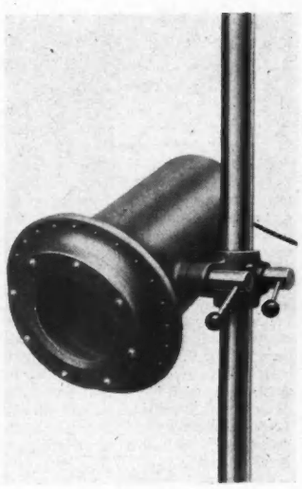
SPOT LIGHT

For Dangerous Areas

NOW AVAILABLE commercially is a range of dust tight and watertight lighting fittings particularly designed for use with closed circuit television systems.

The lamps are made in accordance with the requirements of the War Office and the Ministry of Aviation for use in explosives factories. They can be fitted with lamps of 100 to 250 watts rating according to camera requirements and the permissable surface temperature of the casing. Lamps can be for mains voltage or low voltage according to local needs. The standard housing will take a focusing spot light, a fixed-focus spot, or a flood light.

The body of the casing is a top-hat section spinning in 16 gauge steel measuring 14 in by 8½ in diameter. Riveted to the front is a cast aluminium ring 12 in diameter, and screwed to this is a machined ring into which the 6 in diameter window of ¼ in glass is cemented. For mounting a ¼ in spigot welded to one side fits in the clamp which in turn fits over a 2 in diameter column making



the lamp fully adjustable. Several mounting frames are available. *P. W. Allen and Company Limited, 253 Liverpool Road, London, N1.*

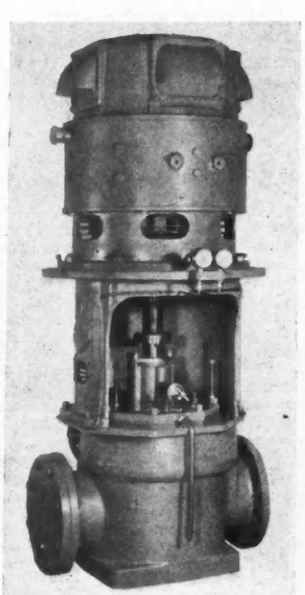
VERTICAL PUMP

Wide Range of Duties

THE DOLPHIN range of vertical pumps was originally intended for marine duties but has proved suitable for many industrial installations.

With only three frame sizes the pumps cover deliveries from 60 to 2,000 gallons per minute by interchanging impellers and diffusers. Maintenance is simple and inexperienced operators can dismantle the entire unit in a matter of minutes.

The main casing has two diametrically opposite suction flanges to give a choice of connection, and the single discharge can be brought to the desired position. The motor support pedestal has a large opening for access to the pump and may be mounted in one of four positions. The impeller is supported by a short heavy section shaft running in a single bearing which may be either grease or water lubricated. Either a soft packed gland or a mechanical seal can be fitted as desired. The bearing and shaft can be made of corrosion resistant materials. *Hamworthy Engineering Limited, Poole, Dorset.*



DIGITAL VOLTMETER

With Print-out Facilities

RECENTLY announced is a dc digital voltmeter model LM902.2.

The instrument is capable of measuring dc voltages from 100 μV to 1·500 kV which are presented as a four digit display in decimal form with polarity discrimination. Display is by means of optical projection and is free from ambiguity. Red and black backgrounds signify positive and negative inputs.

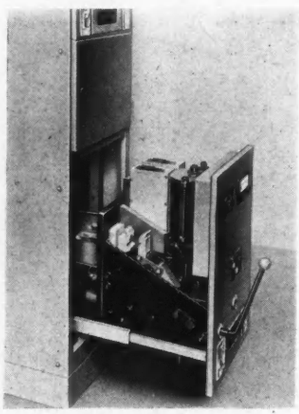
The voltage measurements are covered in five ranges. The input impedance is 10 megohms except on the two lower ranges which have impedances of 1 megohm and 100 kilohms. The long term accuracy is $\pm$ 0·1 per cent of maximum reading on each range. Two additional voltage ranges of 100 V to 1 kV have input impedances of 100 megohms and measuring accuracy of $\pm$ 0·5 per cent.

The readout time is constant at 280 milliseconds irrespective of the voltage input, which may be floated up to 700 V with respect to earth. A check position on the range switch permits zero setting and a calibration check. The internal zener reference can be preset precisely against the built-in Weston cell.

Under auto operation voltages are measured continuously, any variation causing the instrument to display a new reading. The instrument has an adjustable dead zone which can, within limits, make it insensitive to small changes. Thus it is possible to obtain jitter-free readings in the presence of transients. Ripple components at 50 cycles can be attenuated or rejected. In the sample mode of operation a single voltage reading is taken either by manual operation of a panel button or by remote electrical command. This reading will remain until a succeeding sample is taken. Two 50-way sockets at the rear provide information for feeding to a printer. *Solartron Laboratory Instruments Limited, Cox Lane, Chessington, Surrey.*

AIR BREAK SWITCHGEAR

Heavy Duty



A RANGE of flush-fronted air break switchgear is now available for voltages up to 660.

The units are particularly suitable for use with dry type transformers as load centre or packaged substations. Each unit consists basically of flush fronted sheet steel cells in which are housed horizontally isolating double tiered circuit breakers (or off-load isolators) and a central metering panel. The breakers are made for 800A and 1,600A carrying capacity and the former is certified to ASTA class A for 31 MVA and class B for 26 MVA at 415 V while the latter is awaiting certification. They comply with BS 116 : 1952 and BEBS-S3 (1955) and also with the Draft Specification for heavy duty air break circuit breakers.

Closing can be manual, spring assisted, or by solenoid. Opening is by push button. The manual handle can be fitted in various positions to give different operating heights; with spring closing, the spring is charged and tripped in one movement, the closing being independent of the operator. Heavy contact pressure gives high breaking speed. Arc chutes disperse the gases. Provision is made for metering within the overall height of 78½ in. *George Ellison Limited, Perry Bar, Birmingham 22B.*

BORING HEAD

Positive Size Control

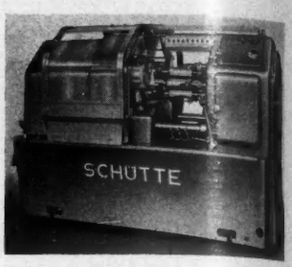
NOW BEING made in this country is the Briney boring head.

The tool is primarily intended for use on fine boring machines working to tolerances of $\pm$ 0·0001 in and the most important feature is the positive control of the boring size. This is obtained by turning the adjusting bush, which is graduated in 0·0002 in divisions, in either direction. The divisions are approximately $\frac{1}{8}$ in apart so that fine setting is possible. It is claimed that there is no backlash in the adjustment.

The head is not limited to one tool bit, and a head which will allow boring, turning, facing and chamfering to be carried out in one operation can be supplied. Bore diameters from $\frac{3}{4}$ in upwards can be handled. Typical work includes the boring of connecting rods, pistons, dowel pin holes, and pump bodies. It is claimed that since the simple adjustment gives a definite bore size, assistance is given to quality control. *Precision Gear Machines and Tools Limited, Bodmin Road, Coventry.*

SIX SPINDLE AUTOMATIC

High Speed



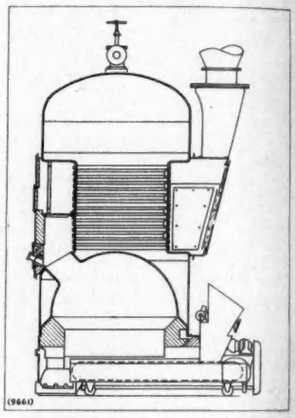
NOW available in this country is the Schütte SE16 high speed six spindle automatic.

The machine has a capacity for round bar up to $\frac{11}{16}$ in diameter with a maximum feed of 4½ in. There are 45 spindle speeds to cover the range from 400 to 5,000 rpm and piece times can be as short as 2 seconds. Power is supplied by a 10 hp motor in the base, the drive being transmitted by V belts to a main shaft from which all movements are derived. The spindles are driven through change gears, and the cam shafts through change gears, rapid approach and feed traverse clutches, and worm shafts.

The tools are mounted in adjustable heads and the feed is by quills. Each work spindle has its own cross slide with independent feed and a longitudinal tool carrier with independent traverse. The spindles are indexed by a Geneva mechanism and have a positive location. Collets are of the draw type. Quills and quill sleeves are hardened and ground and are provided with coarse and fine adjustment. Travel is limited by end stops. Quill feed is by push rods actuated through cams and quadrant levers. Apart from the six push rods, one for each spindle, two further push rods for additional longitudinal movements can be fitted, working on the cross slides for such operations as undercutting. The bar guide assembly is not driven from the spindle drum but from its own Geneva mechanism which can be disengaged to allow loading while the machine is running. Signal lamps indicate the trouble source if one of the six safety stops operates. *Rockwell Machine Tool Company Limited, Welsh Harp, Edgware Road, London, NW2.*

COAL FIRED PACKAGED BOILER

80 Per Cent Efficiency



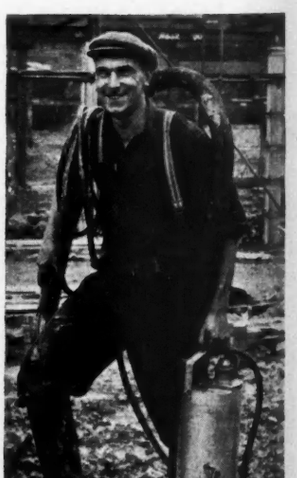
AN EFFICIENCY of 80 per cent reckoned in the gross calorific value is claimed for a new coal fired vertical packaged boiler.

The unit is a development of the Cochran vertical oil fired packaged boiler and has achieved the same working efficiency. Sizes range from 4ft 9in to 9ft diameter with evaporations of 1,750 to 10,000 lb of steam per hour from and at 212° F. The boilers are also suitable for high and low pressure hot water systems.

All welded construction is used with high temperature refractories. The furnace has a domed top and the firing is by a chain grate stoker, chosen as being the best for handling "smalls" and other inferior grades. The tube arrangement is a triple pass with an induced draught fan in the stack. Exhaust gas temperatures are of the order of 480° to 520° F when running at full load. Stoking is automatic and the range of control is large. The grate is mounted on rollers running in channel irons so that it is simple to remove it for maintenance. The ash is discharged at the far end either direct into a small barrow contained within the boiler's skirt or by a worm, as shown in the illustration. The grit carry-over is low. *Cochran and Company, Annan, Limited, Annan, Dumfriesshire.*

DRAINAGE PUMP

6,000 Gallons per hour



SMALLER and lighter than an earlier model, the Minor drainage pump will deliver 6,000 gallons per hour at a head of 29 ft.

The pump outlet is suitable for 2 in bore hose, which can be fitted in a vertical or angled position. Against a head of 52 ft, the pump will deliver 3,000 gallons per hour when running at 2,750 rpm. Power is supplied by a 2 hp motor available for mains supplies from 110 to 550V, 50 to 60 cycles. To the top of the handle, the complete unit measures 2 ft 2 in and the diameter is 7¼ in at the largest point. The weight is 93 lb. A four core screened flexible cable is required, two of the cores being used for the thermostat trip circuit.

The light alloy used is resistant to sea water and to corrosion so the life of the pump is long. It can maintain the water level to a depth of 2 in and will work continuously on snore (pumping a mixture of air and water). *Sumo Pumps Limited, Crawley, Sussex.*

Critical Safety

LACK of stringent control in nuclear engineering could make it the most hazardous pursuit that man can indulge in. Due to the ingenuity of the control systems and the extensive precautions laid down, a remarkable record of safety exists. The number of serious accidents that have occurred in the 19 years since the advent of nuclear power is small. The recent episode with the SL-1 (Stationary Low Power Reactor Number 1) at the United States Atomic Energy Commission's National Reactor Testing Station, Idaho, is an unfortunate mark in the history of nuclear engineering experience. Judging from the preliminary reports that have been published it appears that the reactor was being run with the knowledge that certain things in the core were not correct, although the exact reason for the explosion will not be known until the reactor area can be properly surveyed. The accident cannot therefore be claimed to be caused by the lack of understanding of nuclear physics or poor instrumentation. In the table given below, the main reactor accidents that have been published are shown. Very little is known about incidents behind the Iron Curtain.

Degrees of Accident

Reactor incidents similar to the Windscale experience are fortunately very limited, and so long as the fission products given off can be contained there is very little chance of injurious effects to humans. On the other hand, the financial loss can be considerable and if the reactor has to be shut down there may be further repercussions, since the research programme or the power potential of the reactor will have to be provided for elsewhere.

Supercriticality may occur in chemical or refining plants dealing with fissile materials due to the critical size being surpassed. In refining plants it becomes necessary to calculate every dimension of plant equipment in which fissile material either passes through or collects, in order to check that inadvertant criticality will not occur. The care needed is examplified by an incident at the Oak Ridge National Laboratory in 1958 when concentrated uranyl nitrate solution was being transferred from one part of the chemical plant to another. Somewhere in the line a valve had been accidentally left open, which was intended for draining water into a drum. When the fissile material arrived and was drained into the drum the solution became critical after the level had reached about 9 in, because the drum was not designed to hold fissile material. Fortunately no fatalities occurred but it is easily realised that accidents of this nature are particularly dangerous to human health: this applies to any inadvertent release of radioactive matter, when the cost of material damage is much reduced and tends to become insignificant when compared with a serious reactor accident.

Some Accidents in 1960

Holes in HRE-2: A second hole in the wall of the inner core tank of the second Oak Ridge Homogeneous Reactor Experiment caused it to be shut down. The holes were caused by hot spots made by irregular flow conditions and thus uneven cooling of the fuel. When the tank had been repaired the coolant flow path was reversed which appears to have ended the trouble.

Mishap with Teakettle: Some welded metal falling in the catalyst chamber of the West German reactor caused a gas flow blockage, and the chamber had to be opened in order to make the repair.

WTR Fuel Element Failure: Insufficient inspection and loose fuel specifications were given as the cause of the Westinghouse Testing Reactor fuel element failure. The fuel element used was of a complicated design; it consisted of three concentric fuel tubes with sufficient clearance between each for the coolant to pass, and in the centre a fourth tube used for irradiation purposes. It appeared that a hot spot allowed one of the fuel tubes to expand and eventually the coolant flow was drastically reduced. This caused a fuel element failure and the release of radioactive fission products into the coolant stream. The manufacturing specifications have been tightened to eliminate any chance of faulty engineering recurring.

Fuel Canal Rupture at Marcoule: The G-2 reactor has horizontal fuel canals and the fuel is loaded by releasing a lock and passing another fuel element into the canal. In June, 1960, a rupture occurred between the lock and the fuel canal which allowed some of the closed cycle carbon dioxide cooling gas to escape. The escaping gas being slightly radioactive, rendered it necessary to shut the reactor down and to purge the reactor of all the carbon dioxide. Thus any risk of further radioactive contaminated gas escaping would be eliminated and the mechanical fault could be repaired without any risk of radiation hazard.

Some Reactor Accidents

Date	Reactor	Location	Type of accident
1961			
Jan. 3	Stationary Low Power Reactor (SL-1)	Idaho Falls, Id., USA	Investigation being held
1960			
Nov. 15	Dresden	Dresden, Ill., USA	Control rod failure
July 6	G-2	Marcoule, France	Fuel canal rupture
April 3	Westinghouse Test Reactor (WTR)	Waltz Mill, Pa., USA	Fuel element failure
March	Teakettle	West Berlin, Germany	Coolant gas flow blockage
March 10	General Electric Test Reactor (GETR)	Pleasanton, Cal., USA	Fuel element release of I^{131}
Feb.	HRE-2 (Homogeneous Power Experiment)	Oak Ridge, Tenn., USA	Corrosion hole in core tank
1959			
Dec. 19	JRR-1	Tokai Mura, Japan	Release to containment
Nov. 10	AGN-211 (Aerojet General Nucleonics)	Basel, Switzerland	Scram malfunction
July 24	Sodium Reactor Experiment (SRE)	Santa Susana, Cal., USA	Fuel element failure
Feb. 16	EL-2	Saclay, France	Fuel element rupture
1958			
Dec. 27	EL-2	Saclay, France	Fuel element failure
Nov. 18	ANP	Idaho Falls, Id., USA	Release
Oct. 15	Zero Energy Reactor (ZER)	Vinca, Yugoslavia	Power surge
June 28	Calder Hall	Calder Hall, England	Electrogenerator turbine failure
June 16	Chemical Plant at ORNL	Oak Ridge, Tenn., USA	Criticality during transfer of concentrated uranyl nitrate solution
May 23	NRU	Chalk River, Canada	Power burst in NRU
April 13	EL-3	Saclay, France	Fuel element failure
April 4	HRE-2 (Homogeneous Power Experiment)	Oak Ridge, Tenn., USA	Leak in core tank
1957			
Dec.	Saphir	Wurenlingen, Switzerland	Air pollution
Nov. 26	EL-2	Saclay, France	Converter meltdown
Oct. 10	Windscale	Windscale, England	Burning fuel elements
Feb. 12	Godiva	Los Alamos, NM, USA	Godiva explosion
Jan. 4	Kinetic Experiment on Water Boilers (KEWB)	Santa Susana, Cal., USA	Pump failure
1956			
Nov.	HRE-2 (Homogeneous Power Experiment)	Oak Ridge, Tenn., USA	HRE-2 corrosion
Oct. 26	G-1	Marcoule, France	Fuel element partial burn-up
Sept. 6	Seawolf	Groton, Conn., USA	Sodium corrosion
July 23	Materials Testing Reactor (MTR)	Idaho Falls, Id., USA	Refuelling exposures
1955			
Nov. 29	EBR-1 (Experimental Breeder Reactor)	Arco, Idaho, USA	Meltdown
Nov.	Production Reactor (PR)	Hanford, Wash., USA	Fire in reactor slug
May	Rayleigh Research Reactor (RRR)	Rayleigh, NC, USA	N.C. State Col. corrosion leak
Feb.	JEEP	Kjeller, Norway	Uranium oxidised
1954			
July	Windscale	Windscale, England	Spontaneous energy release
June	Materials Testing Reactor (MTR)	Arco, Idaho, USA	MTR fuel plate melting
Feb. 3	Godiva	Los Alamos, NM, USA	Burst causes disassembly
1953			
	Heavy Water Research Reactor (MWRR)	Soviet Union	Fuel canning failure
1952			
Dec. 12	NRX	Chalk River, Canada	Power surge
Sept.	Windscale	Windscale, England	Accidental release
June 2	CP	Lemont, Ill., USA	Loss of moderator
Dec.	Clementine	Los Alamos, NM, USA	Ruptured fuel element
1949			
Dec.		Los Alamos, NM, USA	Super-criticality
1947-1948			
	Graphite Reactor (Ornl GR)	Oak Ridge, Tenn., USA	Fuel element failure

SL-1 Incident

The riddle of the explosion resulting in the loss of three lives and the release of fission products from the SL-1 reactor (Fig. 1) will remain unsolved until the reactor area can be entered and a more detailed investigation of the surroundings made. Due to a high level of radioactivity in the immediate vicinity of the reactor, it is impossible at present to enter this part of the building for any length of time. The most likely hypothesis put forward so far is that movement of the central control rod permitted a nuclear excursion but the reason for the high pressure that occurred is very difficult to explain. The amount of reactivity controlled by this rod in the original design specification was sufficient to allow criticality to occur if removed a distance of 19 in. However it was known that a variety of conditions had developed in the reactor, some having their origin in the design of the reactor and others in the cumulative effects of reactor operation: these may have contributed to the cause and extent of the accident.

Use of Boron as a Burnable Poison

Prior to the accident the reactor has been shut down for maintenance on the auxilary systems and the only work planned for the core was the insertion of 40 cobalt flux measuring assemblies into the fuel element channels of one quadrant of the core. Access to the core was obtained through nozzles in the head of the reactor vessel and this required removal of the control rod drive assemblies. It was during the reassembly of the control rod drives that the accident occurred. In order for the reactor to remain operative for about three years without a fuel loading burnable poison of boron strips clad in aluminium had been spot welded to the side plates of some of the cruciform fuel elements. The majority of the boron load was placed towards the centre of the reactor and in and the bottom half of the core. The strips accounted for 11 per cent of the reactivity when they were first inserted.

Bowing of the Boron Strips

Early in the life of the reactor it was noticed that the stips were beginning to bow outwards: this continued with time, and slowly the narrow spaces between the individual fuel elements, and the fuel elements and shrouds became serverely reduced. Eventually the removal of the elements in the central region of the core could only be accomplished with great difficulty. At the same time it was noticed that the reactivity of the reactor had begun to increase more rapidly than was expected, until in September, 1960, a net gain of 2 per cent over the expected value had been observed.

Loss in Shut Down Reactivity Margin

To remove the fuel elements required great force and considerable damage occurred to the boron; it was estimated that 18 per cent of the boron had been lost from the core and it was found that the shutdown reactivity margin was only 2 per cent. To increase the margin six cadmium strips were added last November and welded into the unused T-shaped control rod shroud tubes on opposite edges of the core. This increased the shutdown margin by 1 per cent.

Control Rods Sticking

It was frequently found that the control rods stuck in position when the magnetic clutch drive was disconnected in a scram or single rod drop test. This arose from the friction in the seals through which the drive rod shafts penetrated the rack and pinion gear housings on top of the reactor. Over the past two months of operation approximately 40 rod stickings were recorded in the operations log. The situation got so bad that during the last period of operation the rods were assisted manually in their withdrawal, and on scram at shutdown, three rods had to be driven in by their motors. It seems strange that no action had been taken to relieve this serious defect during the maintenance period that the reactor had just been undergoing.

High Power Operation

Before the shutdown in December the reactor had been operating at 4·7 MW(t) instead of the normal 3 MW in order to test a new condenser loop. The effect of the increase in power level gave an increase in the operating water temperature of 5°F, an increase in the radiation levels, and some increase in the turbulence in the core. It was found that the reactor could not be operated at this level with the usual control rod pattern—all removed by an equal amount—without "chugging"; the operation was accomplished with the four outer rods fully out and the centre one in as far as necessary. This had the effect of flux flattening which was in any case partially necessary due to the loss of boron from the central region. From the foregoing it would appear that the SL-1 was far from being in perfect running order. Although these defects may not have been the direct cause of the explosion they may well have aided and abetted.

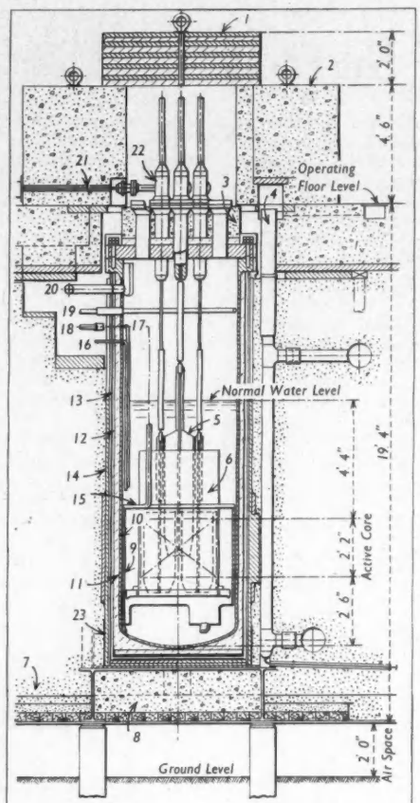
The photograph taken after the event (Fig. 2) shows the metal cover of the pressure vessel shield forced upwards, and the metal punchings and gravel used as shielding have been forced out. Across the top of the reactor head is a shield plug and two more are thought to have been blown up into the roof.

Radiological Units and Measurements

A comprehensive report has been prepared by the International Commission on Radiological Units and Measurements (ICRU). It deals with the basic principles of units, standards and measurements needed in radiation dosimetry, and the specification of radiation treatment. The Commission sets out to evaluate all the data available on the subject of radiation measurement and dosimetry and recommends the most acceptable values for current use. Due to the confusion that exists between the medical and engineering fields and also within these fields themselves, the task before the ICRU is not easy. At the present time a further report is being prepared on the possibility of the total review of all the quantities and units involved in radiation measurements. The report issued in January, 1961, is obtainable from the Superintendent of Documents, US Government Printing Office, Washington 25, DC, priced 65 cents.

Thy Doom is Near

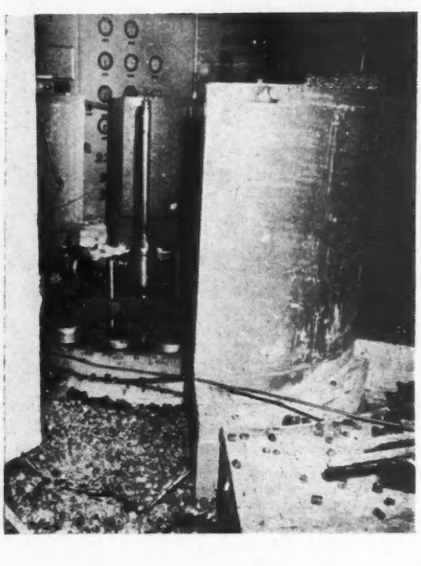
An insurance policy for $10 million (£3,545,000) has been taken out by the Delaware River Port Authority to cover the Benjamin Franklin and Walt Whitman Bridges which go between Philadelphia and New Jersey in the event of a nuclear explosion.



1. Laminated Top Shield
2. Concrete Shield
3. Dry Shield Mixture
4. Instrument Well
5. Control Rod
6. Core Structure
7. Gravel
8. Dry Shield Mixture
9. Thermal Shield
10. Pressure Vessel 4' 6" O.D
11. Insulation
12. Air Space
13. Support Cylinder
14. Lead Thermal Shield and Cooling Coils
15. Feed Water Spray Ring
16. Separator Return Line
17. Purification Purge Line
18. Feed Water Inlet
19. Boron Spray Ring
20. Steam Line
21. Control Rod Drive from Motor
22. Control Rod Drive
23. Boral Shield

Fig. 1 (above) Diagrammatic view of the SL-1.

Fig. 2 (below) View of the SL-1 reactor head after the explosion. The metal punchings and gravel, normally used as shielding material, have been forced out on to the floor area.



Notes and News

VERA—A New Reactor at Aldermaston

VERA (Versatile Experimental Reactor Assembly), a new low power reactor, went critical at AWRE Aldermaston on 22 February, 1961. Since the power rating is under 100W, no cooling is required. It will be used for reactor physics experiments to improve nuclear data and methods of calculation for fast critical assemblies. More information is required on the safety of storage and processing of fissile materials, and for the fast reactor development programme. The work is reported to be coordinated with fast reactor work in progress at other UKAEA establishments.

Reactor Separates for Loading

The reactor has a core region of thin-walled steel fuel tubes surrounded by a natural uranium reflector, forming a cylinder 4 ft high and 5 ft diameter. The fuel tubes are loaded with fissile and diluent material plates 1·7 in sq. and $\frac{1}{8}$ in thick. By appropriate loadings, the composition and size of the reactor core may be varied to examine the nuclear importance of materials over a wide range of neutron energies. The reactor is designed to separate into two parts for safe loading, the two halves being brought slowly together by remote control. An accelerator associated with VERA enables neutron bursts to be generated for measurements of reactivity and time dependent behaviour. The reactor is located in a special cell which is sealed during operation.

Speculation on a Nuclear Powered Ship

The Government are expected to make an announcement shortly of their proposals concerning the nuclear powered merchant ship. It is speculated that the decision will give little encouragement to the firms that have already spent much time preparing tenders and investigating their particular type of reactor. The Government may take the approach of obtaining more land-based experience before building a nuclear powered ship. But Russia has now had the icebreaker Lenin at sea for over a year and the NS Savannah will be making her maiden voyage later this year. Also, the German and Japanese Governments have recently shown strong interest in proposals to build a nuclear ship; if Britain loses this opportunity it may be temporarily more economic but as a long term policy it can only contribute to lowering Britain's status in the shipping field. If the Government do not go ahead on the ship since the nuclear budget is already stretched to the limit, it is to be hoped that they will at least finance the various firms interested in the field to encourage them to continue their work. Many of the firms are disappointed in the way that the Government has treated them and may be tempted to withdraw altogether from the field unless some stimulus is given.

Canadian Confidence Grows

In an inaugural address given at the opening ceremony of the Canada-India reactor in Bombay on 16 January (Atomic Review, 27 Jan. '61), J. L. Gray presented, the Canadian approach to nuclear power. Canada's faith in the heavy water moderated and cooled pressure tube reactor continues undaunted, and 15 years experience with one system will be justified when the results of experiments on CANDU became known, Dr. Gray stated. The problems of controlling leaks of the expensive moderator will be carefully investigated in the NPD reactor for their technical feasibility, and it is hoped that the information will be available later this year. The high burn-up value of 9,750 MWd per tonne has often been criticised. However, metallurgical improvements have allowed higher limits of temperature and further knowledge gained in reactor physics shows that a figure of over 10,000 MWd per tonne appears more feasible according to the latest estimates.

Companies

Elliott Microwave Reciprocal Scheme

ELLIOTT AUTOMATION Limited have completed their negotiations with LITTON INDUSTRIES Incorporated, of California, USA, for cooperation in electron tube and microwave activities.

A new £400,000 company, to be known as ELLIOTT-LITTON, is to be formed. It will assume the responsibility of the chief British and Commonwealth interests of Litton Industries' electron tube division and Elliott's microwave valve business.

Well established in a leading position in the United States electronic industry, Litton, through their electron tube division at San Carlos, California, are one of the principle suppliers of microwave valves in North America. The division provides magnetrons, klystrons, and oscillators for civil and military radar and communication systems. It also manufactures components for satellite systems communications and control.

Elliott have built a substantial export business, particularly to the United States, in high power microwave valves for the millimeter wave bands. Widely expanded market opportunities are expected to flow from the new agreement. The two companies are looking into further ways of cooperating in future.

"Fair Weather" Forecast for Steel

Reporting a group manufacturing and trading profit for the WHITEHEAD IRON AND STEEL Company for the year 1959/60 almost back to the high level of 1955/56, Mr. G. H. Latham, the Whitehead chairman, predicts that all the departments of the company are set for "fair weather" in the current financial year.

Mr. Latham is particularly informative in his annual statement on the relationship between the reduced steel demand from the car manufacturers and the United Kingdom's success as a steel exporter. He recalls that for some time before last year's imposition of higher Bank Rate and the other demand cutting measures, the steel industry had been restricted by the Government in the export field and "ordered to provide better supplies for the booming home industries."

The car industry, perhaps the most sizeable single customer of an important section of the iron and steel industry, is not, in the view of the Whitehead chairman—"the be all and end all of steel sales." The motor industry's recession gave many in iron and steel the opportunity to reclaim their export interests. From the Whitehead company there has come a vigorous drive, coupled with diversification of sales with the result that a larger number of industries are now served at home and overseas than ever before.

This diversification has enabled the company to avoid the effects of recession in the vehicle field which had formerly taken a significant amount of Whitehead's hot and cold rolled steel and cold formed sections. Group manufacturing and trading profit for the year reached £1,367,000, in the previous year it had been down to £864,000. Since 1958/59 was a poor year for iron and steel this is not a very useful comparison. More valuable is the five year comparison given in the table.

Trinister Switches and Mecha-Matic Transmission

WESTINGHOUSE BRAKE AND SIGNAL, whose activities are closely tied up with British Railways' modernisation schemes, are at the same time concerned with some far reaching developments in less familiar fields.

In the Hobbs Mecha-Matic transmission, Westinghouse Brake and Signal believe they have an automatic gearbox, particularly suitable for light cars, of interest to a number of leading vehicle manufacturers. They are preparing to invest heavily in equipping for the production of the gearbox in quantity.

The company became concerned with the Hobbs gearbox when, during the last financial year, they bought a 50 per cent interest in HOBBS TRANSMISSION Limited, who have developed a range of fully automatic transmissions for engines from 900 cc capacity up to 13 litres. It is capable of being used in all types of cars and commercial vehicles. An agreement provides for manufacture by the Westinghouse group for the vehicle industry.

Reduced rates of delivery of freight brakes required by the railways, though slightly increased, continue to affect the fortunes of the Brake division. Road brake equipment orders for commercial vehicles have increased substantially, and a high proportion of these are for export.

In the previous year the Signal and Colliery division was in record production, with the result that the last financial year saw installation work being carried out at double the value of the previous record. Due to the period of Government indecision about the railways, marked by the calling in of committees, the volume of equipment dispatched has fallen. Given the encouraging remarks of the recent White Paper, the company hopes that the railways will now be encouraged to complete their modernisation programme "as quickly as possible."

Two-Way Benefit

In the event of dieselisation gaining ground over electrification, Westinghouse Brake and Signal will still benefit, since a great deal of signalling requires modernisation to allow for the safe passage of greater numbers of trains at higher speeds.

Five Year Earnings by the Whitehead Iron and Steel Company

	1955/56	1956/57	1957/58	1958/59	1959/60
			£'000s		
Manufacturing and trading profit ..	1,387	1,008	1,125	864	1,367
Net income before taxation	1,346	1,004	1,205	924	1,447
Income after tax applicable to group ..	672	477	588	605	731

A new level of orders and sales are reported by the rectifier division. More silicon devices have been added to the production range, including transistors, switching devices known as trinisters and the ancillary control systems. Phenomenal expansion is going on in the semiconductor market, involving Westinghouse in heavy research outlay on products used in telecommunications, traction, and electrochemical and electro-metallurgical plants.

Despite all the activities of the group's parent and subsidiary companies, the trading profit fell by £203,694 to £2,353,794 (1960 was a 52 week year in the Westinghouse account and 1959 had been 53). Much of this reduced trading profit is accounted for by the reduced demand, both home and abroad, for vacuum brakes. This fell particularly upon the GRESHAM AND CRAVEN company, of Manchester. Some improvement is expected this year, but not enough to neutralise the short-term effects of the introduction to this subsidiary of production of the Hobbs automatic transmissions.

Triplex Reorganise Aircraft Glass Section

A virtually new aircraft glass department has been created at the Kings Norton, Birmingham, factory of the TRIPLEX SAFETY GLASS Company by the consolidation of new developments and alterations now completed.

The work is part of the £1 million expansion programme of the Triplex group. Part of the effect will be the doubling of the output of gold film

glass for civil and military aircraft and for diesel locomotives for British railways.

A £13,000 vacuum vessel has been installed in the gold film room in order to deposit on the glass a thin layer of gold which transmits electric current. After additional treatment this layer can carry up to 800 watts per sq. ft. One application of gold film glass is in aircraft cockpit panels, making it possible for the crew to see through the glass under conditions of extreme icing or misting. Two diffusion pumps attached to the vacuum vessel can reduce the vacuum to one or two microns.

The new plant also enables Triplex to process panels with a high degree of curvature not possible with the former equipment. With a new gas expansion refrigerator incorporated in the department it is now possible to reach a temperature of minus 160° F for testing gold film panels. The cockpit panel in the picture has been through stiff refrigeration tests.

The aircraft glass division at Triplex was set up initially to make thick bullet proof glass for aircraft flying in the Second World War. It now produces similar glasses for a very wide variety of uses, including drive-in banks, bullet proof vehicles and ships' wheelhouses. Before the re-organisation this Triplex department made the special glass for Donald Campbell's latest Bluebird.

Commonwealth Investment by British South Africa

However the two Rhodesias and Nyasaland evolve from the present political disagreements one of the companies most closely tied up with the development of those countries is the BRITISH SOUTH AFRICA Company.

Lord Robbins, the BSAC president, has recently released his annual statement, reporting a consolidated profit that has increased over last year by £2 million to £11·5 million, on which the consolidated tax after profit is just over £8 million, the highest in the history of the company by more than £1 million.

In pursuit of diversification within the Commonwealth British South Africa has been making some progress towards investing in real estate in Western Canada. Negotiations are going on for a substantial investment near Vancouver. The company is also involved in the financing of the COMMONWEALTH ALUMINIUM CORPORATION Limited, in which the CONSOLIDATED ZINC CORPORATION is associated with KAISER ALUMINIUM. This concern is going ahead with new aluminium producing capacity in Australia and New Zealand.

The total of this Commonwealth investment by British South Africa is £5¼ million and Lord Robbins says he has heard some criticism of this use of money that could have been invested in the Central African Federation. In reply he points out that the total is a small part of the millions the company has invested in the Federation. The group has other revenues in addition to the mining royalties in Northern Rhodesia and that the right of the group to invest in other parts of the Commonwealth in the best interests of its members cannot be denied. Such investments may in future provide funds for further investment in the Federation.

Lord Robbins emphasises that the primary field for the company is the Federation and refers to the large purchases of land around Salisbury, capital of Southern Rhodesia, and sums made available for agricultural settlement of ex-servicemen. There are heavy maintenance requirements for the company's agricultural and forestry enterprises including a large capital sum for heightening the Mazoe dam and an irrigation scheme for a 3,000 acre extension to the citrus plantations.

Copper production which in the earlier year reached 475,000 tons, rose last year to 560,000 tons in a year free from production losses due to restrictions or strikes. Mining revenue, after paying 20 per cent of the net revenue to the Northern Rhodesian Government, was £11,835,000.

British South Africa contributed £4 million in loan funds to the financing of the great Kariba dam project. Expansion deriving from the flow of Kariba's power is expected for RHODESIAN ALLOYS and RHODESIAN IRON AND STEEL, companies in which the group holds substantial interests.

Sphercon Contact Lens

Boldness in the delicate—an even smaller lens, kept in place by surface tension.

CONTACT lenses appeal to the educated patient —the one who has recognised the value of training himself (or herself) to accept unconsciously the presence of a foreign body in the eye, in preference to wearing spectacles.

Contact lenses owe their growing success to the unflattering appearance and physical inconvenience of spectacles. When worn they are practically invisible, and physical inconvenience becomes virtually non-existent once the patient's eyes become acclimatised. They can also rescue a patient from a state of near-blindness as a result of certain serious eyesight defects. A contact lens is simple and unobtrusive. Its performance depends solely upon its size and shape and the optical properties of the lens material.

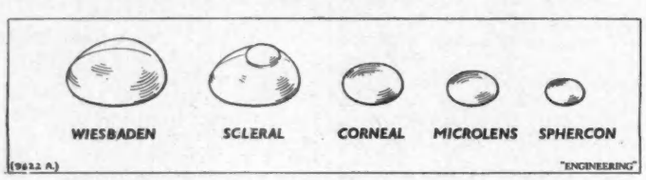
Once a patient has become a convert to the cult of contact lenses as the least obtrusive way of correcting defects of vision, the chances of his returning to spectacles are almost nil. It is largely a matter of initial acceptance. The Sphercon Contact Lens Company Limited of London, W1, under their managing director, Mr. John de Carle, treat the combined factors of education of opticians and service to practitioners as of paramount importance. The company realise that their business of manufacturing and selling contact lenses depends upon the success of this exercise; and their reward is such that in the two years since the company was formed the number of lenses sold has risen rapidly enough to make Sphercon one of the leading contact lens suppliers in Britain.

The degree of public acceptance of contact lenses is much higher in America than in Britain; contact lens users among the population being roughly ten times more numerous on the other side of the Atlantic. Although British contact lens makers may be lagging in quantity they are certainly not behind in design and quality.

Until recent years the development of the contact lens has been painfully slow. It is known that 450 years ago Leonardo da Vinci made a drawing of an eye with a bowl and fluid in front, but though he realised that the eye's refraction could be altered, it is exceedingly doubtful if he realised the importance of the implications. In 1827 Sir John Herschel suggested a contact lens but never, apparently, made any.

The first corneal lenses to be worn successfully were introduced about 1888 when a Dr. Kalt in Paris tried using the bottoms of glass test tubes suitably smoothed and polished. About the same time came the "scleral" lenses which covered the sclera or white of the eye in addition to the pupil and the iris, and were large compared with present-day designs as Fig. 1 shows. About 1948 plastic "corneal" lenses were introduced, so termed because they are confined to the cornea and do not extend beyond the iris of the eye. Today nearly all contact lenses fall into this category. The very small microlenses like the Sphercons are a still smaller form of the corneal and are a more recent development.

Fig. 1 (below) Full-size lens comparison.



The tendency towards size reduction in contact lenses is due to two main factors: (1) unobtrusiveness; and (2) less interference with the normal metabolic processes of the eye such as the exchange of oxygen, carbon dioxide and pre-corneal fluid, and dissipation of heat from the eye surface. On the second factor also depends the wearing time, since the less the obstruction to the exchange processes the longer can the lens be worn without discomfort. The indications are that one day it will be possible for patients to wear contact lenses all the time.

The natural reaction of the eye is to reject foreign bodies, which means that at first the patient will experience discomfort immediately a contact lens is fitted. Furthermore, fitting in itself presents a difficulty due to the natural tendency to flinch and to close the eye. For these two reasons a new patient must voluntarily accept initial discomfort and persevere until they can be worn all day without his feeling them. The importance of educating the patient through the medium of his local ophthalmic practitioner will now be obvious, and Sphercon run periodical supplementary courses in fitting for practitioners.

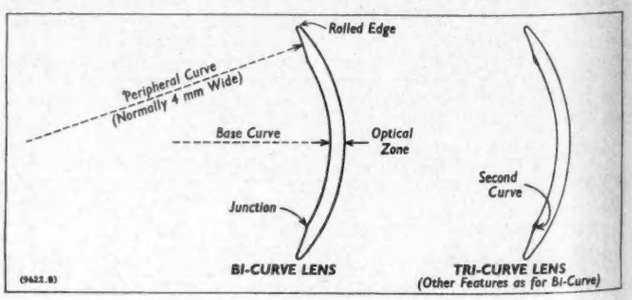
The formation of the Sphercon Contact Lens Company arose from the foresight of Mr. John de Carle who saw the immense possibilities of the corneal contact lens. The use of plastic, introduced about 1945 in place of glass, led to a big upsurge in popularity of the contact lens. Since that time the increase in popularity has been more steady, but lens quality has been improving all the time.

De Carle soon began making contact lenses of his own in limited numbers. To overcome the problem of "plastic memory" inherent in pressings, he cast acrylic plastic between polished dies using dental techniques. His first lenses were supplied by a dental manufacturer using dies of de Carle's own design, but as time went on he engaged more assistants and started casting and developing them himself.

The turning point came in 1957 when de Carle made the first successful bifocal corneal contact lens. He filed patent applications both in Britain and America, and then early in 1958 he happened to send two or three pairs of bifocals to America against an order. As a result he discovered that two American optometrists, Dr. N. K. Wesley and Dr. G. N. Jessen, of the Plastic Contact Lens Company, had been working along similar lines.

It was then agreed that the two sides should get together, and in May, 1959, the Sphercon Contact Lens Company Limited was formed with de Carle as managing director and Wesley and Jessen forming the rest of the board. This alliance enabled the American company to produce and market the hitherto exclusive

Fig. 3 (Right) Bicurve and tricurve lens contours.



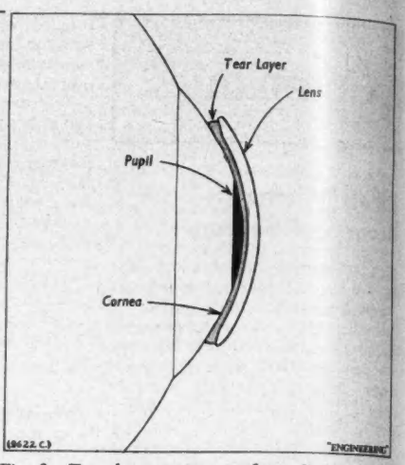


Fig. 2 Tear layer saves eye from direct contact.

de Carle lens designs. In return de Carle received the necessary financial backing and "know-how" to expand his organisation to meet increasing demand, and also improve research facilities. A direct result of the exchange of information with America was the introduction of new manufacturing techniques. Special lathes were purchased for turning lenses direct from acrylic rod, a method which made a significant contribution to reducing lens thickness and increasing accuracy.

FITTING

The name contact lens is a misnomer since at no time is the lens actually in contact with the eye. As Fig. 2 shows, a layer of tear fluid which is part of the eye's natural supply separates the lens from the cornea. Capillary attraction holds the lens in place, and when it is correctly fitted, the thickness of the tear layer will be approximately constant over the area covered, and the lens will tend to remain in the centre of the eye. The diameter of the lens periphery is partly determined by the position of the patient's lower lid in relation to his pupil.

Matching the radius of the inside curve of the lens, known as the base curve, with that of the cornea is naturally an important factor in the fitting of a contact lens. The radius of the patient's cornea is determined optically by using a projection instrument known as a keratometer. Then a trial lens with the appropriate standard base curve is fitted and the patient's eyesight tested in the normal manner with the lens in place. From this test the power of the lens he requires is determined and hence the thickness and outside radius. The power is, of course, a function of the outside radius and the base curve. The reason for testing with the lens in place is that the tear film itself has a refractive index which must be taken into account in determinining the power of lens needed.

The base curve radius of the lens is made to match that of the cornea, for maximum stability and comfort. Standard Sphercon base curves

Fig. 4 A plastic lens, machined on a lathe, fitted to a human eye.

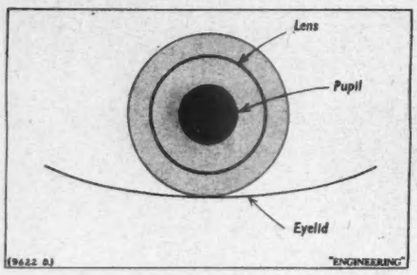


Fig. 5 One correct fitting for corneal lens.

vary in steps of 0·05 mm between 7·3 mm and 8·25 mm radius, and for fitting purposes the practitioner carries a set of test lenses covering this standard range. Lenses outside this range are, however, often required.

Unfortunately, patients' corneas are not always spherical in shape, or even approximately so. One of the symptoms of astigmatism, a fairly common eyesight defect, is that the cornea is distorted and it may be impossible to fit a spherical lens. This condition can be detected by using a fluorescein solution in combination with a trial lens in the eye having the nearest standard base curve. The fluorescein dissolves instantly in the tear fluid and when the eye is examined under black ultra-violet light, variations in tear-film thickness show clearly.

Such cases are a big stumbling block to the fitting of a contact lens, but Sphercon's latest and revolutionary development is the discovery of a way of producing a lens with a toroidal inner surface, in other words, it possesses two different base curves along its perpendicular axes. Lenses so shaped have been given the name "Cycon."

Fig. 3 shows typical lens contours. The purpose of the peripheral curve, normally 12·25 mm radius, is to provide relief around the edges to facilitate the circulation of tear fluid over the eye surface. Present practice is to make the lens a "tri-curve," in which another curve known as the "second curve" is added to reduce the sharp edge effect at the junction of the base and peripheral curves. The radius of the second curve is normally made 0·5 mm greater than the base curve.

Sphercon's policy is to use special tools to expedite lens production despite limitations in space and staff. Shortly they will be transferring manufacture to more spacious premises which will allow necessary further expansion.

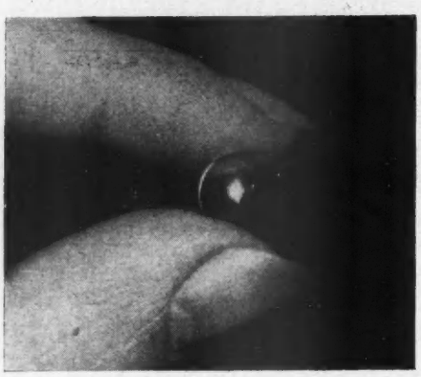


Fig. 6 Standard tricurve Sphercon lens.

PRODUCTION

Corneal lenses start from a 12·7 mm diameter transparent acrylic rod. The rod is fed into a lathe on which lens "slugs" are produced, the first operation being to generate the base curve using a tool with a carefully contoured diamond tip, as shown in Fig. 7. The base curve is then polished and its radius checked by a microspherometer, before the slug is placed in stock.

From here each lens is manufactured against an order originating from the practitioner, which specifies the base curve, centre thickness, power and peripheral diameter. A slug with the appropriate base curve is taken from stock and secured by wax to a holder. The outside curve, whose radius depends, as we have seen, on the base curve and the power, is then generated on a lathe having a dial gauge attachment which enables the finished lens thickness to be accurately maintained see Fig. 8. Tolerance on the thickness is maintained within $\pm$ 0·01 mm.

Polishing by means of a fine paste is performed on the same lathe, then the power is checked by means of an instrument known as a focimeter. The outside diameter is normally 9·2 mm but is variable in steps of 0·05 mm to suit the patient. A press cutter is used which leaves an allowance for hand grinding the peripheral curve and rounding the edge. The second curve is also hand ground, and the lens then has to pass a final examination to make sure all sharp curves have been removed before it is dispatched. The foregoing procedure is for standard lenses giving normal visual correction, which account for roughly 75 per cent of Sphercon's production and which can be dispatched within 24 hours. Special lenses like bifocals and Cycons generally take longer, depending on the contour required.

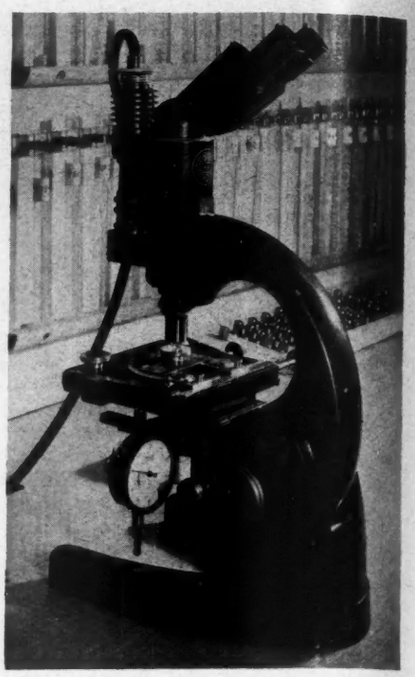


Fig. 9 Microspherometer for checking base curve.

The rapid expansion which Sphercon are experiencing is largely due to the tremendous drive with which the firm are attacking the yet untapped contact lens market. Gradually more practitioners are availing themselves of the Sphercon tuition courses and fitting sets, even though the optician thus equipped is under no obligation to place his orders in their hands. The general situation again illustrates the willingness of the customer of today to pay for quality, as the lenses cost 40 guineas per pair on an average, including the practitioners' service of fitting, changing the lenses and making small adjustments as necessary. Contact lenses are only supplied under the National Health Service in cases of acute need. In certain cases Sphercon are prepared to let a deserving patient have lenses at a nominal charge.

The overseas market is expanding no less than the British, and Sphercon are finding that their lenses are beginning to find favour on the Continent despite the intense competition from established manufacturers.

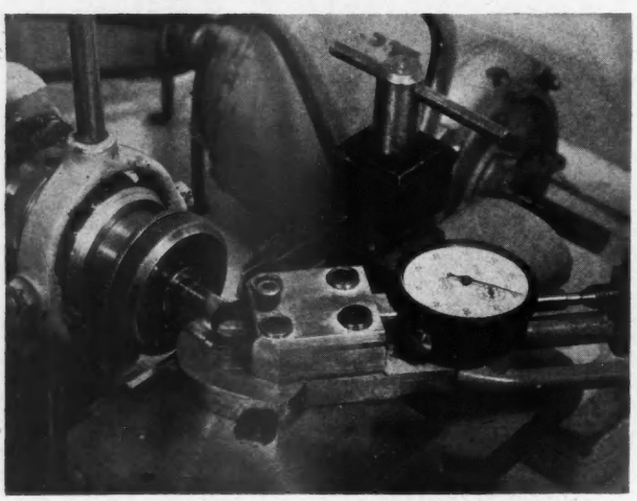


Fig. 7 A lathe with special attachments generating the base curve.

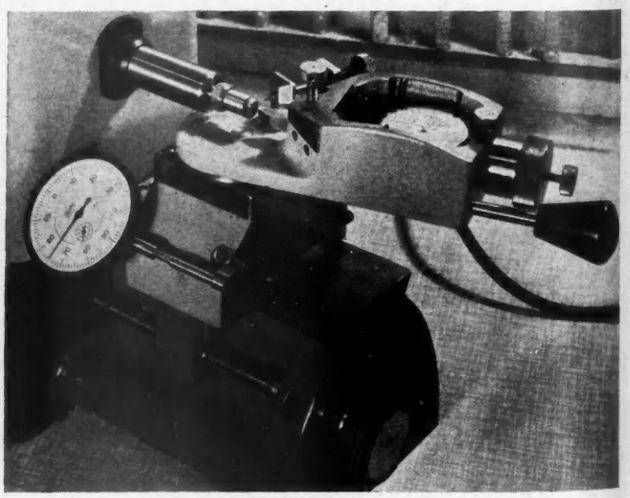


Fig. 8 Specially designed lathe generating the outside curve.

Burning Fuel Smoothly Means More Power

Peak pressure in a petrol engine fluctuates from cycle to cycle, owing to variations in combustion rates. Maximising the peak pressure means more power output without increase in petrol consumption.

THE peak pressure reached in a car engine varies from cycle to cycle. In the past this has been suggested as a cause of engine roughness. The idea has also been put forward that if the peak pressure could be brought up to a uniform maximum level much better engine performance would result. Guesses have been made that 10 per cent more power might be available, with no rise in petrol consumption.

Many things have been blamed for the pressure variations—variations in ignition timing or spark energy, bad carburation, unequal air-fuel ratios, and ill-directed turbulence, to mention a few. But recent tests show that none of these is the chief cause. Moreover, the same experiments show that for normal mixtures a gain in power of only about 2 per cent is possible. Gains of over 10 per cent in power can, however, be achieved when running on very weak mixtures.

In a paper "Cylinder Pressure Variations in Petrol Engines," by J. P. Soltau, the systematic tracking down of the cause of the variations in peak pressure is described. The paper was read before the Automobile Division of the Institution of Mechanical Engineers. The blame was finally found to rest on statistical variations in the length of a certain phase in the burning of the mixture. The only practicable method of reducing the effect of the fluctuations is to increase the speed of burning, which can be effected by igniting the mixture at several points simultaneously by using three sparking plugs, for example.

The author—senior development engineer, Engine Research, Joseph Lucas Limited—used a Renault single-cylinder 500 cu. cm research engine for most experiments. Its compression ratio could be varied from 4·5 to 13 : 1, and various fuel feed and ignition arrangements were possible. For studying the burning process, a similar engine fitted with a quartz-window combustion chamber was used. Photographs were taken with a camera capable of operating at up to 3,000 frames per sec.

As far as the ignition system is concerned, there are six variables that could alter the combustion process. These are the timing of the spark in relation to the piston position, the energy content of the discharge, the physical configuration of the sparking-plug electrodes, the type of spark, the number of ignition sources, and the igniter position. Variation of each of these in turn over a wide range showed that only by increasing the number of sparking plugs could the pressure fluctuations be evened out. The effect obtained is shown in the graph. Fluctuations that normally occur in the other variables—torsional vibrations in the spark timing drive, for example—were found not to account for the pressure variations.

Numerous high-speed colour cinematographic records were taken during normal running of the transparent cylinder head engine. When these were anlysed it was immediately apparent that the combustion process varied greatly from cycle to cycle. The principal variable is the delay period between the occurrence of the spark and the formation of a stable reaction front. After the front has been formed the flame moves across the chamber at a fairly constant speed. The third stage of combustion starts behind the premixed, blue-flame reaction zone and lasts an appreciable time after the whole gas charge is alight. It is this third stage that is the most important part of the combustion process, as most of the heat is released then. Unfortunately, it varies from cycle to cycle, a slow reaction always being obtained after a long delay period. When several ignition sources are used, the average delay period of the several parcels of gas become more consistent, and a repeatable main reaction follows.

The air-fuel ratio was found to have a very great influence on the cycle-to-cycle behaviour. The most stable combustion occurs with an air-fuel ratio in the region of 13. It is less for low compression ratios and higher for higher ones, taking a middle value at around 9 : 1. As the air-fuel ratio range is traversed, and as the mixture becomes either richer or weaker the deviation of peak pressures and also of indicated mean effective pressures from the mean increases. It is mainly this effect that prohibits the use of very weak mixtures and produces the characteristic mixture loop. Near the limit of burnability, there is a no sharp dividing line where it could be said that the mixture on one side burnt and on the other did not burn; there is a very wide band where decreasingly efficient combustion can be maintained, as every cycle has a different efficient burnable limit.

If it were possible to run an engine and obtain in each cycle the pressure equivalent to the highest recorded under fluctuating conditions, then gains of over 20 per cent in both power and economy could be achieved at an air-fuel-ratio of 18 and above. The stabilising effect of multi-spark ignition diminishes slowly as the air-fuel ratio is weakened; but fortunately the rise in indicated mean effective pressure obtainable makes it a worthwhile proposition if operation at the lean end of the mixture range is required.

To achieve the improvement possible with three sparking plugs it is essential that the plugs fire simultaneously. The only practical system of ensuring that they do was found to be by using three coils in series, triggered by a single contact breaker.

Some connection was found between the type of fuel used and the cycle to cycle variations in peak pressure and i.m.e.p. Fuels with a more rapid average combustion speed are less prone to give wide differences—the less time spent on burning and the more on expansion, the more repeatable will be the cycle.

All hydrocarbon fuels exhibit the same kind of fluctuations, although their severity changes slightly with chemical composition. A fuel such as town gas, which is rich in hydrogen, suffers only small variations, as both diffusion and flame spread are extremely rapid. There was nothing to choose between one commercial petrol and another, and the choice must remain purely an economic one. A premixed charge obtained with a gaseous fuel such as butane or methane does not show less peak pressure fluctuation than a liquid fuel mixture that is either carburetted or sprayed in the manifold. Thus, the mixing of liquid carburant and air must be adequate.

Whatever means of supplying the fuel is chosen, similar fluctuations are present. The mixture can either be a premixed gas or an injected petrol spray in the manifold air stream; the liquid fuel can be sprayed continuously or only when the inlet valve is opened; and there is no noticeable difference in either peak pressure variations or differences in power from cycle to cycle. If cylinder-head injection is used, however, there can be very great scatter if both the injector and the sparking plug are not well placed.

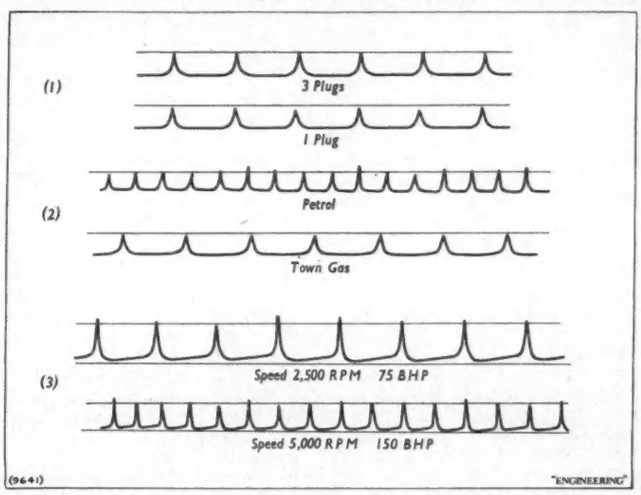
In the various experiments carried out, similar peak pressure variations were observed under all conditions of load. But the presence of residual exhaust products tended to have a detrimental effect. Under idling conditions at 500 rpm, for example, appreciable differences in pressures could be seen even with a fuel such as town gas.

There appears to be a steadying trend as the compression ratio—and, therefore, the scavenging and temperature—increases. Even with a fully scavenged cycle some fluctuations are present but combustion is much more rapid. On the test engine no compression ratio was tried above 12 : 1, but the author considers that it can safely be assumed that at, say, 20 : 1, with the throttle wide open, conditions would be very similar to those occurring with a fully scavenged cycle at a lower ratio.

To obtain fully scavenged conditions, the test engine was fed in the normal manner, using manifold petrol injection, but instead of the charge being ignited every fourth stroke it was ignited every fourth cycle. Since the exhaust gas concentration decreases as the square of the number of cycles that do not fire, three idle cycles were sufficient to obtain a clean gas charge. Observations showed that exhaust gas dilution was a much more important factor than increase in charge temperature and pressure.

No research was conducted into the influence of squish turbulence, but it was noted that the quartz-window engine, which in its 9 : 1 compression ratio form has an appreciable squish area, was less prone to large pressure fluctuations than the Renault engine, which had a hemispherical open combustion chamber.

Although the greater part of the tests were made on a well-instrumented research engine under ideal conditions, similar pressure traces can be obtained on any current production car engine. For comparison, the pressure trace obtained on a 6 cylinder overhead-valve racing-car engine of very great efficiency is shown. An investigation was also made on a 10 in bore stationary gas engine that ran on chemical-plant waste gas. In this case the peak-to-peak variations were very bad, even as much as 40 per cent.



(1) Pressure fluctuations from cycle to cycle are much reduced by using three sparking plugs (top) instead of one (bottom).

(2) Fast burning fuels such as town gas exhibit smaller fluctuations than slower burning fuels such as petrol.

(3) Peak pressure fluctuations occur in all production engines. This is the trace recorded from an extremely efficient racing car engine.

On the Shelf

By Frank H. Smith

I AM not much given to sentiment—or am I?—but I like to think that A. E. Matthews, in his little dressing room in Heaven, is able to get hold of a copy of the *Esso Magazine*, winter 1960-61. There is the most delightful illustrated article in it entitled " Lighting up your Street," and all that is best in lanterns is illustrated. In these days of elongated penguins-cum-giraffes-cum-ostriches, the article is full of nostalgia and I am glad to know that I live in a sufficiently retarded district that all the streets have not yet fallen to bleach-lights. We still have what I now know (thanks to this article) to be the Windsor Lantern. It is a sobering thought that clock control started to oust the lamplighter as early as 1868—two years after the birth of the brightest weekly.

Some of you will know that some time ago the hitherto Aero Research Laboratories of Duxford (the people who make things stick) became CIBA (A.R.L.) Ltd. but still go on making things stick. They have now issued an " Aeroweb " Honeycomb Production Information Sheet No. 1 entitled " Permissible Bonding Pressures with 'Aeroweb ' Honeycomb Core Material," and, with it, they send an up-to-date set of " 'Aeroweb ' Design Information Sheets." As if this is not enough, they will supply those interested with a loose leaf binder, i.e. a binder to take loose leaves. Just the thing for autumn gardening.

Attracted (or repulsed) by the word " dismantleability " as the title of the editorial in the January *Canadian Aeronautical Journal*, I read on. This is, it seems, a technique they have evolved to enable those who wish to extract any paper to do so without affecting the number's " bindability " (they have the grace to put both words in quotes). You destaple it (my word) and take out what you want and leave the rest intact. In other words, if a paper does not happen to finish on a left-hand page (and only one does not) the next left-hand page is left blank. Librarians! Watch your pagination when you bind. A larger left-hand margin is allowed and the journal has a standard three holes punched in it. Spoon-feeding, I call it.

(I cannot reproduce them all here or even make a selection, but Collet's record shop have some most intriguing lists of folk music, Russian records, and Israeli folksongs. 70 New Oxford Street, London, W1).

I believe this column has the reputation for being pretty up to date with news of forthcomings but naturally (said he, with modestly lowered lashes) I cannot cover the lot. One of the nearest approaches to this achievement is H. K. Lewis's " New Books and New Editions " of which No. 348 (January, 1961) covers Nov.-Dec. 1960. The aim is, of course, primarily to sell you the books, but " this list will be sent regularly post free to any address on application." Simply add " & Co. Ltd. " to that name, and address them at PO Box 66, 136 Gower Street, London, WC1. I know everybody knows this but it is possible that you are not everybody.

Self-Changing Gears Limited (so handy in a crowded dressing-room), of Lythalls Lane, Coventry, are cheering because their *Transmission Times* (no connection with ITV or BBC) circulation is up to 4,000. They are quite prepared to push that figure higher if all you lot care to write to be put on the mailing list. K. Montrose is the lad to get in touch with and he, strange though it may seem, is the publicity manager.

I hope that next time Dubonnet run a competition in *Life* they will choose a non-aeronautical question. I have been swamped by people asking who first flew through the Arc de Triomphe and when? I hope the answer I gave was the right one and that Dubonnet have some sorting out to do.

Amorphous Crystallite

Borate Glasses. By L. YA. MAZELEV. *Consultants Bureau Enterprises, 227 West 17th Street, New York 11.* ($10)

Recent work in Russia on the melting, formation, processing and physical and chemical properties of glass systems in which boric oxide is the sole or principal " glass-former " is treated in this book, which comprises a collection of original papers. Each paper provides also a short survey of previous work.

The programme covered was apparently stimulated by the conclusion, generally agreed upon at the Leningrad Conference of 1953, that glass has an amorphous crystallite structure, as opposed to the Zachariasen concept of a completely random atomic arrangement. It was also appreciated that the problems of the volume and role of the ordered section in glass and their effect on glass properties, and of the changes in glass properties with changes in composition remained unsolved. This stage in the development of a theory of glass structure was reached as a result of studies on silicate, and, to a very limited extent, borosilicate glasses.

In the introduction, it is emphasised that the rules developed for one type of glass cannot be extended to cover another type, and hence the attempt was made to provide an extension of the structure postulated for silicate glasses to borate glasses. This is a very ambitious project, in that, in the first place, due to the very small amount of available basic information, it involves an experimental survey of the complete field of borate glass; secondly, the ideas on silicate glass structure have to be applied to a different system with the additional complication of the phenomenon known as the " boric oxide anomaly."

This anomaly is a particular manifestation of the non-additive character of the change in the properties of glasses with a continuous change in their composition, and has been related to the possibility of a structural change in borate glasses associated with a change from BO_3 to BO_4 structural groups. A further complication, which appears to have been introduced deliberately, lies in the fact that a high proportion of the oxide systems studied contain lithium and beryllium, the presence of which confers additional anomalous behaviour.

The discussions in the various papers on the structural implications of the experimental results of the studies of crystallisation in borate systems, the solubility of the glasses in water and their physico-chemical properties require very careful reading and a high degree of theoretical knowledge.

Details are given of the experimental techniques utilised or specially evolved for the purpose of the various investigations. These include a procedure for the chemical analysis of the prepared glasses, the application of differential thermal analysis and thermogravimetric analysis to the reactions of glass formation and the method adopted for determination of chemical stability of the products. The wide variety of property-composition relationships includes measurements of density, thermal expansion, refractive index, absorption of X-rays and of thermal neutrons.

One paper gives a critical appreciation of procedures for the calculation of the physical properties of a borate glass having a known chemical composition. Finally, an appendix provides tables setting out the compositions of about 1,000 borate glasses, principally in the system B_2O_3-Li_2O-RO together with their physicochemical properties. There are also nearly 200 references.

It cannot be said that a complete theory of the structure of borate glasses has been evolved; this is too much to expect. What the book does provide is the basic scientific foundation for progress in the development of such a theory. On the more practical aspects of the usage and possible applications of borate glasses in many fields the information provided is invaluable, in that it is collected together for the first time and by far the greater amount is completely new.

H. COLE

Systematic Vigilance

Electronic Equipment Reliability. By G. W. A. DUMMER and N. GRIFFIN. *Pitman.* (45*s*)

Statistical Processes and Reliability Engineering. By DIMITRIS N. CHORAFAS. *Van Nostrand, Princeton, New Jersey and London.* (96*s*)

Modern Probability Theory and its Applications. By EMANUEL PARZEN. *Wiley, New York and London.* (84*s*)

Engineers are becoming increasingly reliability minded nowadays, as well they might, for even the layman and the popular press have been directing some rather pointed questions at them, following the recent unfortunate series of breakdowns on our railways. Nevertheless, progress is being made, at least in some fields, and reliability is, in fact, becoming a technology in its own right. New generations of specialists, describing themselves as " reliability engineers," are arising. Meetings and symposia on various aspects of reliability are being frequently held and there is an ever increasing spate of publications reflecting the growing interest in the subject.

The three textbooks which form the subject of this review are good examples of this interest. They differ considerably among themselves and cover various aspects of a very wide field. The first, by Dummer and Griffin, attempts to summarise present knowledge as applied to electronic equipment, in order, it is said, " to assist designers and users in obtaining maximum reliability in their equipment." This is a worthy enough aim and, if the authors do not altogether succeed, it is not through their lack of diligence in skilfully and attractively presenting a mass of relevant information drawn from the particular fields of activity (namely the Services) with which they are familiar.

Their lack of complete success results, rather, from the inherent difficulty of summarising and adapting such information into a form which can be of direct assistance to designers and users in other than Service fields and of giving them firm guidance, apart from that which they are already likely to have available as members of a works development team. These, indeed, are the days of the big batallions, and reliability is more likely to follow from the skilfully integrated efforts of various specialists coupled with the corporate experience which accumulates from operating in a big way.

Such experience, to be relevant to future problems, is very difficult to express in the short compass of a textbook. Too often a relatively small oversight of some phenomenon never mentioned in the literature can have devastating consequences. Reliability is, indeed, closely linked with constant vigilance within an organisation. Moreover, designers are usually circumscribed by considerations of cost, an important topic, about which the present book is curiously silent.

A valuable feature, however, is some guidance to the published literature on reliability in the form of an annotated bibiliography. It can be fairly said that in Dummer and Griffin's book nearly everyone concerned with the problem of reliability will find enough of interest to warrant the modest outlay of 45*s*, but that too much should not be expected of it.

The second book, by Chorafas, *Statistical*

Processes and Reliability, is of quite a different type. The field which it covers is even wider than its title implies since it would also be of interest to engineers and others engaged in systems planning work in which a general knowledge of statistics can profitably be applied to a wide variety of its associated problems.

Despite the assurance given on the cover that "Part A, 'engineering statistics' gives a systematic and mathematically complete presentation of statistical techniques," the book can hardly be recommended as a textbook complete in itself; a certain familiarity with the formal mathematics of statistics must be regarded as a prerequisite to its true appreciation and understanding. No topic is dealt with in sufficient detail to provide systematic training for the beginner.

In so far as it relates statistical processes with reliability engineering, however, it is very practical. Statistics, which the author defines as "the science of making decisions based on incomplete information," can be a very powerful tool if intelligently applied. By its means, maximum operating reliability at a given cost, or alternatively, minimum cost for a specified operating reliability, can be achieved in considering, for example, the design of electronic units.

Of particular interest in this connection is the author's exposition of the concept of "Monte Carlo," a method of solving engineering problems which is growing in popularity. This and other topics are all covered from the engineering planning, rather than the mathematical standpoint. A preliminary reading of the last chapter (Part F) is bound to provoke any engineer having a taste for statistics to study the foregoing chapters (Parts A to E). The book is undoubtedly a valuable addition to the literature on both reliability and systems planning engineering.

Parzen's book on *Modern Probability Theory and its Applications* is a textbook which can be safely recommended to the mathematically minded student of physics or engineering who can contemplate a much deeper incursion into mathematical statistics with equanimity. Even those who are already qualified will, however, profit by reading the first chapter on "probability theory as the study of mathematical models of random phenomena," which, in its way, is really excellent.

Throughout the book the assumptions are of the academic type normally made by mathematicians, but no indication is given of the limitations which these impose on the deductions. Each chapter is followed by a number of examples specially designed to provide exercise in the theory, but which seldom have much relation to engineering experience. Nevertheless, it is refreshing to find that, in an otherwise austere work, many of these examples are enlivened with humour. Those who have the inclination, ability and perseverance to assimilate the text and work through the examples would certainly emerge very well equipped in the logic of statistics.

If, in addition to this, they can acquire the ability to assess the true validity of their assumptions, they could then very profitably tackle those facets of reliability engineering which lend themselves to the statistical approach.

J. K. WEBB

Trackless Locomotive and Mobile Power Plant

The Development of the English Traction Engine. By RONALD H. CLARK. *Goose and Son Ltd., 10 Davey Place, Norwich.* (84*s*)

The Development of the English Steam Traction Engine, by Ronald H. Clark, A.M.I.Mech.E., is a monumental and comprehensive history of the engine from 1834 until the present day. I say advisedly "until the present day" because despite the fact that the steam traction engine has gone entirely out of favour for utilitarian purposes it is still on show in all its glory and running as well as ever at the rallies held every year in various parts of this country and in New Zealand.

The whole history of the traction engine is covered in great detail and it is astounding even to an old designer to read of the great number of engineers who at one time or another made these vehicles.

The author deserves great credit for his success in unearthing information regarding the very early examples. The time taken and the journeys made to collect the information must have been very considerable. The photographs and line drawings are excellent and convey to the mind the machine and its development with great clarity.

As the author states, the early engines were to some extent based on locomotive practice as instanced by the under-mounted engine; but the top mounted engine speedily came into favour and so remained to the end. The chain drive to the rear wheels had but a short reign and was superseded by gear wheels which had cast teeth that usually got better with use. Many types of reversing gear are illustrated, but the Stephenson link motion seemed to be the favourite. Road wheels proved somewhat of a problem and the author illustrates and describes the many devices to obtain low ground pressure and high tractive effort on soft ground. Many types of boilers are illustrated, the locomotive type with fire tubes being most often favoured.

The enthusiasts who organise rallies and those who are attracted thereto will read this book with great zest, and having read it, the owners of traction engines will no doubt redouble their efforts to maintain the engines in almost new condition with all the shine and colour which was the pride of the original owners.

The book should have a great appeal to model makers as it contains all the information necessary to enable a first-class working model to be made. The detailed information given in the appendices at the end of the book covers all the main particulars of the various types and sizes of traction engines made by all the principal manufacturers.

A wonderful book of 390 pages and 582 illustrations and line drawings, it reflects great credit on the author who must have spent years of investigation all over England.

W. RIGBY

Strike Action—Legal and Constitutional

Trade Unions and the Government. By V. L. ALLEN. *Longmans.* (35*s*)

Trade Union Law. By NORMAN ARTHUR CITRINE. 2nd edition. *Stevens and Sons.* (105*s*)

Two recent books to augment the ever-increasing literature on trade unions are V. L. Allen's *Trade Unions and the Government* and *Trade Union Law*, by N. A. Citrine, although it is open to question whether the latter, being a second edition, can legitimately be classified as an addition.

Dr. Allen's book, which is divided into five main sections, gives an historical analysis of the relationship between British trade unions and Government, with particular reference to the influence unions exert on Government decision-making. The author in this work, which will eventually form one volume of a larger study concerning the impact of trade unions in Britain since 1918, does not discuss local issues but confines himself to national trade union activity and central government.

In the book's first part he examines the effect unions have had as pressure groups on government, the part taken by union representatives on Government bodies, and the Government's influence as a conciliator and arbitrator. In this way, the constitutional relationship between unions and government is developed for the reader. The second part deals with government as an employer—at present the largest in the country—and traces the history and consequences of labour problems in the civil service and in nationalised industries.

There follows a discussion on government attitude to strikes, which many readers will find among the most interesting in the whole book. In one passage, for example, the author appears to offer advice on how employees in a nationalised undertaking can most successfully carry out strike action. The fourth part attempts to analyse the importance of the trade union movement when a Labour Government is in power. Finally, Dr. Allen sums up the main points he has made and includes in his summary an assessment of the general influence trade unions have had on Government.

Although the book is well written and extremely informative, some people may experience difficulty in accepting all the views which the author holds. He states, for example, that "the intellectual influence of union leaders in the Cabinet has never been very great except in the case of Ernest Bevin." This may very well be an unfair generalisation, especially about those trade unionists who had only very limited opportunity to display their abilities in the 1924 and 1929 Labour cabinets.

The statement, too, that "union leaders who join the cabinet try hard to act in what they consider to be the national interest and discard sectional loyalties," appears to be a veiled criticism implying that these men had bitten the hand which fed them. Another controversial point is the author's footnote concerning the suggestion that a law should be introduced to make it compulsory for trade unions to hold secret ballots before strikes could be called. Without offering any reason, he maintains that it is false to assume that in many strikes ordinary members do not want to strike and if allowed to express their opinions secretly would say so.

In addition to these criticisms which are, after all, only ones of detail, another and perhaps more serious fault is to be found. In my opinion, the author displays a certain bias in favour of trade unions as compared to government, be it Labour or Conservative. His concluding sentence, where he states that "it would be preferable if the power of other organised groups in society (industrialists, the church, the press, the establishment and the aristocracy) were as constrained and directed with such social purpose" as that of unions, seems to sum up this bias and may fail to find general acceptance.

But none of the criticism which has been made seriously affects the book's intrinsic value. Its strength probably lies in the depth of understanding which Dr. Allen gained from his informal discussions with trade union leaders and former cabinet ministers and besides supplying students with a valuable, if at times controversial, textbook, the work because of its attractive and readable style will certainly provide interested laymen with a clear-headed account of

the relationship between trade unions and government.

Trade Union Law on the other hand is almost exclusively a reference book for the professional adviser and trade union official, and a textbook for the student. The first edition, published in 1950, has become widely acknowledged as the authoritative book on the subject and while no dramatic legislation affecting trade unions has been enacted during the succeeding decade, Mr. Citrine considers that a second edition is now appropriate in view of the number of important changes which have taken place in the relevant law.

Basically the work has not altered. It opens with an historical account of the measures relating to the organisation and payment of labour and the circumstances behind their enactment. Two legal doctrines, restraint of trade and conspiracy, are also discussed in this section. The introduction is purposely straightforward and is intended purely to supply background information. The author then examines in detail specific trade union Acts and relevant Criminal Law. The final part is made up of comprehensive appendices which supply, *inter alia*, information on miscellaneous statutes, specimen rules and examples of forms for the proper conduct of union business. The size of these appendices has been reduced slightly from the previous edition but without detriment. An excellent index and glossary of legal terms, both features of the first edition, complete the book.

Yet in the light of what has been said in the preceding paragraph, there may be people who will question the necessity for issuing a second edition at this time. What, in fact, are the "important" changes involved? The prohibition of strikes and lockouts introduced in 1940 was discontinued in Great Britain in 1951 and in Northern Ireland eight years later. March 1959 witnessed the termination of the Industrial Disputes Order, 1951, which in Great Britain made available compulsory arbitration for industrial "disputes" as an alternative to strikes and lockouts and provided for the legal enforcement of collective agreements. This latter part was subsequently introduced into permanent legislation by the passing of the Terms and Conditions of Employment Act 1959.

As the statutory definition of "trade union" includes trade combinations having as their object "the imposing of restrictive conditions" the Restrictive Trade Practices Act 1956, under which such bodies are controlled, has been included. The author also deals with judicial decisions relating to trade unions and in particular with perhaps the most far-reaching one, Bonsor *v* Musicians Union (1956), which seems to establish that a registered union can sue and be sued for breach of contract.

Although the space which Mr. Citrine has been able to allocate to this post-1950 legislation is small when compared with the book's overall length (656 pages), the changes, which are most adequately detailed and discussed, represent significant landmarks in trade union law and consequently this revised edition with its erudite commentary will be welcomed by those who require such a reference book. There is little doubt that they will be unanimous in their opinion that the publication of the second edition of *Trade Union Law* is fully justified.

E. M. QUINN

Understanding German Mathematics

Grundlagen der Analysis. By EDMUND LANDAU. 3rd edition. *Chelsea Publishing Co., 50 E. Fordham Road, New York 68.* ($1·95)

Any beginner who wishes to learn to read German mathematical works and requires an elementary text might well turn to this paper-back. The book itself first appeared 30 years ago, and has run through a number of editions. Now it has been reissued with complete translations of the prefaces, and a complete glossary at the end.

One of the difficulties of coming to grips with mathematical texts in any language is that they rarely tell the reader how to speak aloud the signs which are used. This little book is on the whole good in this respect, though in a number of cases the pronunciation of a sign is not given until it has already been used a number of times. Some of the easier difficulties are clarified *ad nauseam*, for example (= *sprich: gleich*) whereas others such as $(x')'$ are not mentioned at all. If this book is reprinted again, more editorial work is needed, and a glossary of signs at the end would be a useful addition.

While the book affords a useful starting point for the beginner, it needs to be supplemented by another with a much wider range of mathematical vocabulary, to include the usual symbols of the differential and integral calculus. The reviewer does not know of one, nor does he know where a glossary of mathematical signs may be found either in English or in German. Perhaps some reader of ENGINEERING can help.

D. B. WELBOURN

The Reviewers

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New Books

A New Survey of the BBC Experimental Colour Transmissions. By I. R. ATKINS, A. R. STANLEY and S. N. WATSON. BBC Engineering Monograph No. 32. *British Broadcasting Corporation, 75 Marylebone High Street, London, W1.* (5*s*)

This paper, which is in some respects a sequel to the monograph published in May 1958 immediately after the completion of the programme, describes the transmissions in detail, and considers the suitability of the existing distribution network for colour.

Space Biology. By JAMES STEPHEN HANRAHAN and DAVID BUSHNELL. *Thames and Hudson.* (35*s*)

The three main sections of this survey of the human factors in space flight cover the vehicle itself, its air pressure, atmosphere, and food, water and wastes systems; acceleration forces and weightlessness; and radiation hazards. An introductory section traces the literary history of space travel thought from Leonardo da Vinci to Buck Rogers.

The Antenna. By L. THOUREL. *Chapman and Hall.* (70*s*)

Essentially a manual for use in planning antenna systems for specific requirements. It is based on a course given at the Ecole Nationale de l'Aviation Civile, and aims to provide a précis of information on antenna techniques and types for the working engineer.

Symposium on Durability and Weathering of Structural Sandwich Constructions, San Francisco, 13 October 1959. ASTM Special Technical Publication No. 270. *American Society for Testing Materials, 1916 Race Street, Philadelphia 7, Pa.* ($3, *members* $2·40)

In 1955 a series of exposure programmes for sandwich panels was initiated at two ASTM sites, in North Carolina and Pennsylvania. The completion of the first series prompted this symposium to consider experience and applications in aircraft and building construction.

Thermal Engineering. By HARRY L. SOLBERG, ORVILLE C. CROMER and ALBERT R. SPALDING. *Wiley, New York and London.* (76*s*)

Based on the authors' earlier *Elementary Heat Power*, the present book sets out to give the student the necessary coverage of thermal power systems to serve as an introduction to major courses in thermodynamics, fluid mechanics and heat transfer.

Sixth National Symposium on Vacuum Technology: Transactions, October, 1959. Edited by C. ROBERT MEISSNER. *Published for the American Vacuum Society by Pergamon Press, New York and London.* (120*s*)

A total of 58 papers were presented, grouped into the following categories: spectroscopy in vacuum science; high and ultra-high vacuum systems; vacuum measuring techniques; vacuum system applications; scientific applications; thin films and vaporising sources; components; and ionic pumping. The present volume also includes a list of contents of the whole series so far, with a cumulated index of authors.

The Banker's Guide to Marine Insurance of Goods. By VICTOR DOVER and GORDON ANTHONY CALVER. *H. F. and G. Witherby Limited.* (70*s*)

Specially written to provide in a readily accessible form the knowledge of insurance that is needed by a banker who is concerned with the finance of imports and exports. The appendices include specimen forms, phraseology, and case law.

Introduction to Mechanics, Matter, and Waves. By UNO INGARD and WILLIAM L. KRAUSHAAR. *Addison-Wesley Publishing Company, Reading, Massachusetts, and London.* (53*s*)

A textbook for the first year of a two-year course in general physics as offered to students of science and engineering, and for intermediate level courses in mechanics and related subjects. Concurrent study of calculus is assumed.

Trade Publications

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Plant

Vacuum Driers. APEX CONSTRUCTION LTD., 15 Soho Square, London, W1. "Rotacone" vacuum driers with operating capacities from 0·39 to 226 cu. ft. Leaflet 111.

Distillation Plant. BENNIS THERMOFLASH LTD., Little Hulton, Walkden, Manchester. Thermoflash water distillation plant described in principle and detail. 12 pp. ill.

Process Equipment. APEX CONTSRUCTION LTD., 15 Soho Square, London, W1. Process equipment for the pharmaceutical, chemical and metallurgical industries. Including mixers, blenders, driers and presses. Catalogue Ex 58, 8 pp ill.

Wrapping and Filling Machines. D. C. & YOUNG (ENGINEERS) LTD., 6 Argall Avenue, Leyton, London, E10. Tonazzi machines for cartoning, wrapping, and filling tubes and bottles. Various leaflets; ill.

Hydro-Pneumatic Accumulator. FAWCETT PRESTON & CO. LTD., Bromborough, Cheshire. Greer-Mercier hydro-pneumatic accumulators. Nominal sizes from 10 cu. in to 8 gallons. 6 pp. ill.

Screens. SAXON ENGINEERING CO. LTD., Royal Street, Fenton, Stoke-on-Trent. Single and double deck vibratory and reciprocating screens with handling capacities up to 400 tons per hour. Brochure, 16 pp., ill.

Marketing

Water Storage Heaters the Only Bright Spot

THE YEAR 1960 is a year the electrical appliance manufacturers would really rather prefer quietly to forget.

The Electricity Council's statistics on new appliances sold by the area electricity boards in England and Wales show that over the whole year washing machine sales were down by a third (32·2 per cent), refrigerators were down by 15·8 per cent, electric cookers were up by only 1·2 per cent.

There was a substantial increase in the number of water storage heaters (11·3 per cent) and a small (1·9 per cent) improvement over the year before in the number of immersion water heaters sold.

When comparison is made between last December's sales and the board's sales in the previous December there is an even bigger disparity. Washing machines are down by 47·8 per cent, refrigerators by 21·5 per cent, cookers are down by 3·5 per cent and clothes dryers for which no estimate is available against the year before, the decline on the month's sales was 36·3 per cent.

The Central Electricity Generating Board in the 12 months up to the end of last March sold the grand total of 92,575 million kWh. This figure of total power sales, leaving out sales to the South of Scotland Board, has risen since 1955 as follows:

Year ending 31 March	Million kWh
1955	63,467
1956	68,960
1957	72,437
1958	79,285
1959	83,961
1960	92,575

School of Chemistry and Supermarket Contracts

Preparatory work for Bristol University's new School of Chemistry is one of two West Country orders, together worth almost £250,000, to be carried out by HOLLAND & HANNEN AND CUBITTS (GREAT BRITAIN) Limited.

Site preparation includes 40,000 cu. yd of excavation, of which 12,000 cu. yd is in rock. A 500 ft retaining wall is to be built varying in height from 13 to 25 ft. Foundations for the first teaching block will also be built.

The second contract is for Keynsham Urban District Council in the first phase of the redevelopment of Bath Hill, Keynsham, Somerset, as a civic centre. Old property is being cleared from the site for the building of an L-shaped two storey block of shops including a supermarket and car parks.

Machine Tool Orders Double in a Year

Although export deliveries by the United Kingdom machine tool firms were greater (£2,606,000) in November of last year than the new export orders booked in the same month (£2,375,000), the total order book for the industry was still double the value of twelve months earlier.

The home orders at the end of the month, according to figures recently released by the MACHINE TOOL TRADES ASSOCIATION, were £80,774,000, against £39,284,000 in November, 1959. The export orders were £22,934,000 compared with £16,592,000.

Export deliveries during last November were almost a million pounds higher than a year earlier, £2·6 million as against £1·7 million. Home deliveries during the month had gone up from £5·6 million to £6·4 million.

While new orders were not coming in quite so fast as in some of the earlier months of the year they were still being received at a rate the Machine Tool Trades Association is able to call "brisk." A consistent element of the trading pattern of the year is the faster increase in export than in home deliveries.

£19 Million Contract for West Burton Boilers

The boiler plant for the CENTRAL ELECTRICITY GENERATING BOARD's 2,000 MW power station to be built at West Burton, Nottinghamshire, is to be provided by INTERNATIONAL COMBUSTION Limited.

CEGB's order, the largest single contract for steam generating equipment ever placed with the company, is for four 500 MW reheat boiler units.

The design of the boiler units is a development from the 550 MW International Combustion boiler installation ordered in 1959 for the Thorpe Marsh power station, in the Board's Yorkshire division. Each unit is arranged as a single sub-divided furnace employing tangential firing of the fuel from six mill units of the pressure type. The full load can be carried by any five mill units leaving one in reserve for standby and maintenance purposes.

Full operational service of the first 500 MW unit is due to begin in June, 1965, and the other three are planned to come into use at intervals of nine months.

The operating conditions of the West Burton boilers are to be:

Primary steam evaporation, 3,450,000 lb-hr
Steam pressure, 2,400 lb per sq. in
Steam temperature, 1,055° F
Reheat steam temperature, 1,055° F

Turbo-Generators from English Electric

Four 500 MW single-line turbo-alternators, worth together almost £15 million, are to be built for West Burton by ENGLISH ELECTRIC.

The company are alone among British turbine manufacturers in being in production with a complete range of large single-line units. Each of the first machines of the progressively increasing ratings has been ordered from English Electric.

The successive stages of increasing output have included these steps:

1955, first 200 MW
1958, first 275 MW
1959, first 350 MW
1961, first 500 MW

All these sets used steam at about 2,300 lb per sq. in, 1,050° F with 1,000° F reheat.

Last year the CEGB placed an order for one of its two first 375 MW supercritical sets with the company. These sets are to use steam at 3,500 lb per sq. in and 1,100° F with reheat to 1,050° F.

German Car Boom against World Trend

The sharply differing fortunes of the car industries in Western Germany, Austalia and the United Kingdom have been emphasised by the announcement of the reduction in car sales tax in Australia and the booming production figures for January attained by the German manufacturers.

Production of cars and estate cars in Western Germany in January was 174,179, an increase of 24 per cent over January, 1960, and almost 2,000 more than the industry's previous best in March of last year. The total for all vehicles, 197,367, was also 24 per cent above the level of a year before. Exports, which had reached a record level in December, climbed again, to 95,989 vehicles.

Although the German firms have many more cars in stock than at this time in 1960 or in the January before that there is every sign that the manufacturers are confident of a lift in demand before this year's early Easter.

A different situation exists in Australia where some 5,000 employees have been dismissed from the vehicle industry and only a proportion of them are expected to be taken back in the near future. The Australian Government has announced the reduction of the car sales tax from 40 per cent to 30 per cent, in an effort to modify the postponement of demand brought on by the expectation that the increased tax (it went up to 40 per cent only last November) would not last beyond the next Australian budget.

Market Caution

This has been welcomed by the Society of Motor Manufacturers and Traders as a step which can be expected to improve the market for British cars in Australia. Exports from British car firms to Australia fell swiftly towards the end of 1960.

On the United Kingdom home market there is more than a little caution in making predictions of likely car market prospects. Short time working has fallen sharply and with factories back on the five-day week talk of new models is increasing. But from the Midlands there are warning voices querying how long the recovery can be expected to last.

A clue to the basic premises of the motor firm managements, who are all pressing on with major additions to capacity, lies in the observation of the general manager of BMC's AUSTIN MOTOR Company, that by 1971 the home market will need 1,700,000 replacement cars every year.

Rootes USA Advertising Cleared by Commission

Charges of false advertising are not to be pressed under a settlement of the United States Federal Trade Commission accepted by ROOTES MOTORS INCORPORATED, importers of cars to the USA.

The settlement agreement, requiring the company not to advertise that parts and services are immediately available in places or at times when they are not, was said by the Rootes' general manager to be in practice not a restriction at all, as his company had never advertised in a manner prohibited by the settlement and had no plans to do so.

Rootes have a 600 dealer network throughout the United States making parts and service available over a wide area. The company had offered to show the Federal Commission that its spare parts reserve was substantial enough to justify the claims made.

Visitors Among the Cracking Towers

Showing people around your plant is an enlightened form of self interest and BRITISH PETROLEUM go in for it on a scale appropriate to the size of the company and its operations. The three principal BP refineries in Britain were toured by 15,430 visitors last year. They came from schools, universities, clubs, societies and other bodies.

To the Isle of Grain refinery in Kent came 9,135 visitors. The Grangemouth refinery in Scotland was seen by 1,643 people and the Finnart ocean terminal at Loch Long also received a number of callers, among them a group from the ORGANISATION FOR EUROPEAN ECONOMIC COOPERATION.

£1 Million Continuous Steel Casting Plant

A £1 million plant for the continuous casting of steel, believed to be the largest of its kind in the world, has been placed by SHELTON IRON AND STEEL, of Stoke-on-Trent, a subsidiary of JOHN SUMMERS, with the DISTINGTON ENGINEERING Company, of Workington, a UNITED STEEL COMPANIES subsidiary.

The installation will be made up of four vertical continuous casting machines with a total of 13 strands able to cast billets varying widely in size. Two 45 ton converters are to provide the steel for the plant. The continuous casting plant is to be built under licence from CONCAST A.G., of Zurich, with whom Distington are associated in this specialised field.

Computer Control for Power Plant Boiler

BABCOCK AND WILCOX have ordered the new Argus computer system from FERRANTI for installation at the West Thurrock, Essex, CENTRAL ELECTRICITY GENERATING BOARD station.

Costing about £75,000, the computer will control the starting up and shutting down of a 200 MW boiler and will be the first computer to be employed for this type of works operation.

At a cost of around £60,000 a similar system has been placed on order by IMPERIAL CHEMICAL INDUSTRIES for automatic control of a chemical plant at Fleetwood, Lancashire. This unit will take over from 100 conventional control machines.

The CEGB's Argus system will employ two printers giving information on what is being done at the command of the computer and setting out how the boiler is behaving and, at selected intervals, what the temperatures are, and so on.

Digital Computer Controls Large Plants

Two recently ordered electronic digital computers are to be used to control actively a chemical plant and the start-up and shut-down of a 200 MW boiler.

ARGUS computing systems, made by Ferranti Limited, have just been ordered by Imperial Chemical Industries Limited and Babcock and Wilcox Limited to control two significant installations.

ICI's Argus is to be used for the automatic control of a chemical plant. This order marks something of a turning point in the use of the electronic computer in Britain, extending its role from that of a passive instrument to an active means of control. The computer will be an integral part of the plant it is controlling and the results of the calculations made in it will not simply be recorded for action by a human operator. Instead, they will take the form of electrical signals which directly control operations in the plant.

The system is to be installed in one of ICI's plants at Fleetwood, Lancashire, where it will take over the functions of about one hundred conventional control devices. It is expected to be in operation by June, this year.

Babcock and Wilcox have ordered their computer for the Central Electricity Generating Board to control the start-up and shut-down of a 200 MW boiler in the new electricity generating station under construction by the Board's Southern Project Group at West Thurrock, Essex. This arises from a two year design study carried out by a group appointed by the CEGB.

Receiving information from conventional instrumentation, the computer system will perform all preliminary checks before starting up the unit. It will then start up individual items of plant such as fans and coal pulverisers, and meanwhile will adjust the set-points of the analogue controllers to bring the boiler up to load as quickly as possible, while maintaining all necessary limits such as maximum metal temperatures in superheaters.

THE COMPUTER

The Argus digital computer was designed with the control of industrial processes specifically in mind, and the electronic circuits are constituted entirely from solid state components. The machine uses binary serial/parallel fixed-point arithmetic and a word length which may be either 12 or 24 bits. On 12 bit numbers, addition is carried out in 20 microseconds, multiplication in an average of 100 microseconds and division in 200 microseconds.

Programming the machine is done manually by inserting small ferrite pegs into holes grilled in printed circuits arranged in trays. These trays form the programme stores. Reading out of the stored information is done by energising the printed conductors on one face of a tray, and the pegs cause currents to be induced in certain of the conductors on the other face, depending on the pattern in which the pegs are inserted. The high speed working store is a magnetic core matrix. Backing up storage of 50,000 words can be provided by magnetic drum.

One special feature of the machine is a facility which enables the main programme to be interrupted at regular intervals to allow a special routine of instructions to be carried out—as may be required for regularly examining some quantity in the controlled process and taking necessary corrective action. Another facility allows for direct writing into or reading out of the magnetic core store by independent equipment, such as magnetic tape units, which cannot be synchronised with the computer.

Peripheral equipment available enables all types of electrical signals to be selected and converted to binary form. It also provides output signals to fulfil all the control and data-logging requirements normally associated with the operation of industrial plant.

The individual computing units from which the computer is built up are versatile components of solid state, printed circuit, package construction with 36 packages to a box. These boxes can be assembled very quickly indeed to form numerous different types of digital control systems.

CHEMICAL PLANT

It has not been disclosed which particular ICI plant the Argus system is being supplied to. However, whichever one it is, when the installation of new instrumentation became necessary, it was decided to centralise all the control loops in a digital computer rather than to install a large number of individual analogue controllers in a conventional system.

The installed price of the digital control system is slightly higher than that of the conventional analogue system but the central availability of all process data in the former offers many benefits which could not otherwise be achieved. For example, the process variables will be logged on magnetic tape in such a way as to facilitate mathematical analysis of the plant characteristics on another computer (a Ferranti Mercury). The knowledge gained in this way will gradually be incorporated into the Argus programme so that, ultimately, the independent control loops which are built into it will be subject to overall supervision by a master section of the programme.

About 100 individual control loops will be replaced by the computer, which will have a programme capacity of 1,024 instructions and core storage for 1,024 words. Over 300 analogue signals of six different types are to be read in, one group of 100 points being selected in a total time of $\frac{1}{10}$ second. Outputs for controlling the settings of nearly 100 pneumatically operated valves are also being provided.

The fact that the computer operates directly on the process is the most important feature of this application. A more orthodox approach would have been for the computer to operate through the agency of conventional controllers or in parallel with them, to guard against the possibility of equipment failure. The inherent reliability of the computing equipment coupled with the docile nature of the process which it is controlling guard against the possibility of equipment failure. In addition, the Argus is one of the few process computers available which is sufficiently fast to carry out this form of direct control of a large number of loops.

BOILER CONTROL

For the boiler application, the programme store of the computer will have a capacity of 4,096 instructions, and the working store a capacity of 1,024 words. The input equipment is designed to accept a total of 171 analogue signals from 97 transmitters and 32 three-term electronic controllers. In addition, digital signals are accepted from 675 on/off devices. Readings from 150 thermocouples will also be selected for checking metal and bearing temperatures.

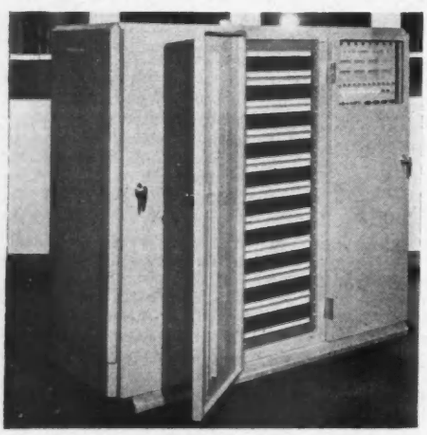
The computer output equipment provides digital drives to about 150 contactors, for controlling motors and actuators.

Two printers will be used for monitoring and logging purposes. The first will be an operations printer which will continuously provide information on what the computer is doing and how the plant is behaving; the second will print out, at regular intervals, the various temperatures, pressures, etc., attained in the boiler, and also calculated figures indicating the efficiency and performance of the unit.

In addition to carrying out the functions of control and data logging, the computer monitors all the essential alarm points and operating equipment many times each second, thereby providing an additional safeguard against dangerous conditions arising through equipment failure or variations in the operating conditions of the plant.

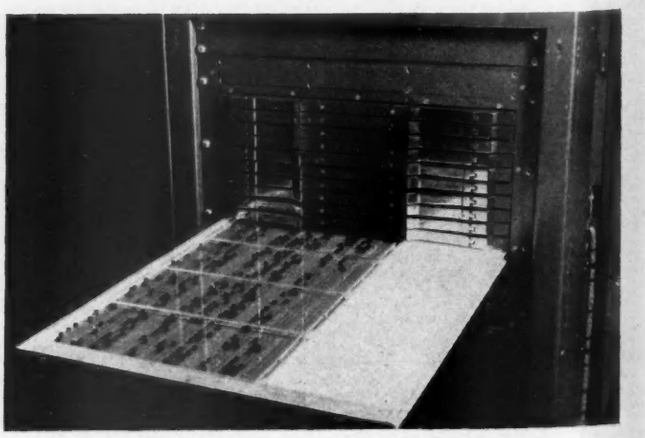
EFFICIENCY

The Argus control system used in this way ensures consistent performance when bringing a large power unit on load in the shortest possible time, operating it at maximum efficiency under varying loads, and shutting it down safely and quickly when necessary. All the information concerning the boiler is available centrally and the performance and efficiency of the unit can readily be assessed.



(Left) The main unit of the Argus process control computer.

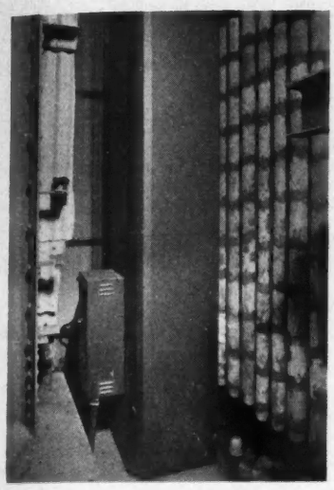
(Right) The Argus is programmed by inserting small ferrite pegs into these trays, which can be removed for the purpose.



Preventing Losses of Molten Metal

The General Electric Company Limited has devised an infra red plant for the drying of stoppers for 90-150 ton ladles at the Clydebridge Steelworks of Colvilles Limited, at Cambuslang. In the past, a great deal of molten metal has run to waste when stoppers for these ladles have exploded. The explosions have resulted from the improper drying and subsequent expansion of the cement that joins the short lengths of cylindrically shaped ceramic bricks forming the stoppers.

Standard sheathed wire element reflector units in a vertical sheet metal casing make up the



Ladle stoppers entering the infra red drying oven.

infra red drying plant which has a loading of 56 kW. As the stoppers are made, they are lifted upright by a small electric hoisting block and on to a moving conveyor. Up to 90 stoppers can be carried on the conveyor which takes them into the oven, three at a time, for a 20 to 30 minute drying period, depending on the diameter of the stopper. The completely dry ladle stoppers are lifted from the conveyor by an overhead crane and placed directly inside the ladle in which they are to be used.

Previously, the stoppers were hung near the furnaces to dry, or placed in an inefficient gas heated oven. Apart from the cement often drying unevenly, these methods were also much slower.

Annealing Brass Strip

To increase output and thus offer quicker deliveries, Earle, Bourne and Company Limited, tube manufacturers and suppliers of rolled metals, have installed four new heat treatment furnaces. Designed and built by GWB Furnaces Limited, of Dudley, the four electric batch furnaces will be used for the annealing of brass strip. The complete installation comprises not only the furnaces but also a heavy duty steelworks type turntable charging machine of Gibbons-van-Marle design and five loading tables.

Earle, Bourne cast their own metal and the billets are then rolled through Robertson strip rolling mills into a wide variety of strip widths and gauges. Intermediate and final annealing of this strip, essential processes in its production, are carried out in the GWB furnaces. The coils are heated in a temperature usually in the range of 500° C, to 600° C, withdrawn from the furnaces by the new charging machine and allowed to cool in air. The company hopes to install a cooling tank in the near future so that the coils can be quenched immediately after leaving the furnaces.

All four furnaces were installed at the end of last year. The heating chambers are 20 ft long, by 5 ft wide, by 3 ft 6 in high to the crown of the door opening. Each furnace is rated at 342 kW in three zones and is designed for operation up to a maximum temperature of 750° C. Two of the four furnaces are equipped with reduced rating input control so that they may operate, with very close temperature uniformity, at lower temperatures for charges requiring stress relieving.

The hearth incorporates three grooves to accommodate the arms of the charging machine, the piers being formed in single-piece, specially-moulded firebrick blocks. These piers are topped with heavy cast 24/12 nickel-chromium alloy heat resisting steel plates, as are the walls of each groove which guide the charger's arm rollers. Arranged in sinuous form and fitted under the arched roof and in the hearth of the heating chamber, the heating elements are made from 80/20 nickel-chromium strip. Door elements are in the form of nickel-chromium wire coils and supported upon refractories incorporated in the door lining brickwork.

Each furnace is fitted with a counterbalanced door framed with mild steel and refractory faced. The drive for the door lift is obtained from an electric drive unit consisting of a motor transmitting through the necessary reduction gearbox and spur wheel drive on to a main shaft, the latter being fitted with sprockets and chains attached by lugs to the door. Automatic clamps and continuous asbestos seals reduce leakage of heat or infiltration of cold air when the door is closed.

Five waffler type air circulating fans are fitted in the roof of each chamber, use being made of an independent motor drive.

Each furnace's electrical equipment comprises a switchgear cubicle working in conjunction with an Ellison oil immersed circuit breaker, and the temperature control is from three Electroflo indicating controllers and an Electroflo three-point recorder. Safety contacts are fitted to these recorders so that the main electric supply is cut off automatically in the event of accidental overheating, so isolating the furnace.

At the present time the furnaces are working 24 hours a day. Before they were installed Earle, Bourne sent out to other companies the greater majority of their annealing work, but now they have a complete, up to date and well organised production line which will undoubtedly step up the company's output of brass strip.

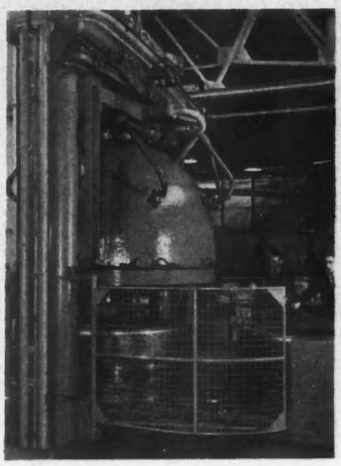
New Rubber Press Technique

Boulton Paul Aircraft Limited of Wolverhampton, after nearly three years' development work, are now operating a "Suproform" hydraulic rubber press for the production of a wide range of metal pressings ranging from tableware to motor car components. This new press employs a conventional shaping die, but pressure is applied through an elastic diaphragm which itself is under pressure from a liquefied rubber medium held in a large domed chamber.

The manufacturers claim that this new rubber press technique provides a financial saving of up to 90 per cent as compared with mechanical press tool costs.

In providing various equipment, such as tableware for hospitals and the home, press sheet metalwork for the aircraft and motor industries and ornamental panels for the building trade, the Suproform press is said to offer considerable advantages over the orthodox rubber bolster press. One of the most important of these is that the surface of the material produced is free from blemish.

A second important consideration is that the reaction to the variable pressing load, ranging up to 5,000 lb per sq. in, is transmitted entirely through the locking means holding the fluid pressure chamber and the rigid closure of platen together, so that the heavy hydraulic rams and supporting pillars and frames used in conventional presses are unnecessary.



The unconventional Suproform press uses liquefied rubber as a pressure medium.

Metal Bonding

Head Wrightson Teesdale Limited, a subsidiary of Head Wrightson and Company Limited, have supplied to the de Havilland Aircraft Company Limited a press which is capable of exerting a thrust of 3,000 tons. The press is designed for the Redux process of metal to metal bonding by adhesion under temperature and pressure control. It has a clear table access of 36 ft by 9 ft and is of welded construction.

The four main rams are each 750 tons capacity single acting and are arranged within the corner posts. They are flange mounted to the top platen with pivot reactions between the rams and thrust plates. Upward travel is arranged through four secondary rams each of 100 tons capacity and mounted in line with the main rams. Automatic levelling of the press is obtained by differential control between main and secondary cylinders.

The 3,000 ton press during installation.

Process controls for Reduxing operation together with the necessary press controls are housed in a combined cubicle suitably positioned to give a clear view of the press. The pumps and valve assemblies are arranged below floor level adjacent to the press and the two prefill tanks are positioned above the cylinders between the corner posts, one at each side. Guards are arranged at all access points and safety keys are provided to ensure that all guards are proved down before operation of the press can commence.

Comprehensive Study of Nuclear Fuels

Engineering's first Research Report presents the results of a study of nuclear fuels; including uranium, uranium alloys, uranium oxide, uranium carbide and uranium oxide-stainless steel cermets.

THE desirable features of a nuclear fuel are dimensional stability and the ability to give high total burnups at high heat ratings. To understand the applications of various fuels it is useful to consider the expression applicable to rod type elements.

$$q = 4\pi \int_{\theta_s}^{\theta_{max}} k(\theta)\, d\theta$$

where q = maximum heat rating
$k(\theta)$ = thermal conductivity expressed as a function of temperature
θ_s = fuel surface temperature
θ_{max} = maximum premissible central temperature.

For a given fuel $k(\theta)$ is fixed and as it is desirable to have θ_s as high as possible to give a more efficient steam cycle, the heat ratings can only be increased by increasing θ_{max}.

Uranium Metal

Natural uranium is, on economic grounds, the first choice as a fuel but there is, neglecting irradiation effects, an apparent limit to θ_{max} at the α-β phase change at 660° C. To determine if in fact fuel rods could be taken through the α-β change, experiments simulating the thermal conditions in a reactor when 660° C is exceeded have shown that cycling through the phase change causes permanent distortion when more than 10 per cent of the bar diameter is transformed to β; other effects are recrystallisation and changes in overall orientation around the transformed region. The effects can be explained on the basis of a simple model of phase change cycling damage generally applicable to other metals such as iron. The practical conclusion from these results is that uranium fuel rods can certainly not be used continuously above 660° C.

Another phenomenon which may limit the maximum operating temperature of uranium metal is swelling under irradiation. This is due to the accumulation of fission product gases but the mechanism by which these precipitate and cause swelling is complex and at present incompletely understood. The internal stresses generated by irradiation and thermal cycling are a contributing factor; these stresses arise because of the anisotropic structure of α uranium and their magnitude has been calculated under various conditions. In the case of creep under thermal cycling the accuracy of the calculations has been verified by experiment. Fig. 1 is a plot of the creep acceleration factor due to thermal cycling against the ratio of the externally applied stress (W) in the creep test to the internal stress (I) generated by thermal cycling. The effect of thermal cycling on creep is large, e.g. creep is accelerated 20 times by the application of $a \pm 40°$ C cycle to a test at 500° C and 0·5 tons per sq. in. This creep work has relevance to problems concerning the bowing of fuel rods and the collapse of tubular fuel elements.

Irradiation growth is another phenomenon which affects the dimensional stability of uranium metal fuel below 500° C. This is due to the change in shape which α uranium crystals undergo when bombarded with neutrons. To limit the harmful effects of this in fuel rods great care is taken to produce a fine grained and randomly oriented metal. Because uranium scatters X-rays more than other metals it is difficult to detect preferred orientations in uranium by X-ray crystallography. A technique which avoids this difficulty and gives a measure of preferred orientation has been developed. This involves the measurement of electrical resistivity and thermal expansion both of which are very anisotropic properties but do not vary correspondingly in specific crystallographic directions.

TABLE.—*Properties of Fuels*

Property	Uranium	Uranium oxide	Uranium carbide	Uranium oxide stainless steel cermet 60/40w/o
Density g/ml ..	19·0	10·96	13·62	9·49
Uranium density, g/ml	19·0	9·66	12·96	5·80
Melting point °C	1,1130	2,750	2,450	1,450 (metal)
Maximum operating temperature, °C ..	550	1,400	1,400	1,000
Thermal conductivity at 600° C* c.g.s. units	0·08	0·009	0·049	0·028
Permissible heat output in rod form (independent of diameter), kW/ft θ_s = 400 C°	19·0	11·0	77	27
θ_s = 600 C°	0	9·0	61	18

* Unirradiated.

Uranium Alloys

Unalloyed uranium can give heat reatings of up to 15 kW per ft and expected total burn-ups of 3,000 MWD/Te (megawatt days per tonne); with 1·5 w/o (per cent by weight) molybdenum and zirconium additions, it is known that burn-ups of at least 6,000 MWD/Te can be achieved. To understand the effect of alloying, a metallographic study has been made of the microstructural features in uranium rich binary alloys containing molybdenum and zirconium, using both optical and electron microscopic techniques, as the microstructural condition may be one of the metallurgical variables influencing irradiation damage.

The microstructures of heat treated unalloyed uranium and cast uranium—1·5 w/o molybdenum are shown in Figs. 2 and 3 respectively. The structure of the alloy under both polarised light 3 (*a*) and normal illumination 3 (*b*) is refined and under normal illumination consists of two phases, α uranium and γ type second phase. The form and distribution of these phases are governed by heat treatment, the rate of cooling being especially important. When annealed at 950° C or 800° C followed by furnace cooling, uranium when alloyed with molybdenum or zirconium, develops structures which consist of α grains surrounded by the more isotropic γ-second phase in varying amounts depending on the alloy content.

Together with the study of second phase distribution, introduced by alloying and heat treatment, long term annealing tests up to 600° C have shown that alloys containing more than 1·5 w/o molybdenum and 5 w/o zirconium, when heat treated as described, are thermally stable. This feature is considered desirable because the ensuing changes with temperature and time may effect the irradiation damage processes in an adverse fashion.

In conjunction with this metallurgical work, an irradiation programme to study growth and swelling of uranium with and without alloy additions, has been undertaken in collaboration with AGIP Nucleare and CNEN (Comitato Nazionale per L'Energia Nucleare). The specimens and rigs have been prepared at NRC and the irradiation will be performed in the Italian Ispra reactor.

Ceramic Fuels

The main disadvantage of metallic fuels is that they can only be used at comparatively low temperatures and this limits the efficiency of the steam cycle. To obtain useful heat ratings at higher surface temperatures it is necessary to use materials which will withstand a higher θ_{max} and it is in such cases that ceramic fuels are employed.

Uranium Dioxide

Of the ceramic fuels, uranium dioxide is the one at present most favoured because of its irradiation and crystallographic stability, relative chemical inertness to proposed coolants and low thermal neutron absorption cross section. However its thermal conductivity is comparatively low and although it is crystallographically stable to its melting point (2,750° C) the maximum central temperature is limited to approximately 1,400° C by the release of the fission gases Kr and Xe. Gas release from oxide is by a diffusion mechanism but varies with the density of the sintered material, the fabrication route and the temperature. It has been found convenient to characterise gas release from sintered material by an expression D/a^2 where D is the diffusion coefficient of the particular inert gas in completely dense material and "a" is the radius of a hypothetical sphere of completely dense material which would release gas at the same rate as the sintered materials, a is thus a measure of the diffusion distance to a free surface: the larger the value of a the smaller the gas release. It is thus important to know the factors which determine a. Values of a can be determined directly by comparing the release of fission gas from sintered material with the release from dense fused material. However, a values of sintered material can be determined from surface area measurements by the expression:

$a = \frac{3\,d}{S}$, where d is the fraction theoretical

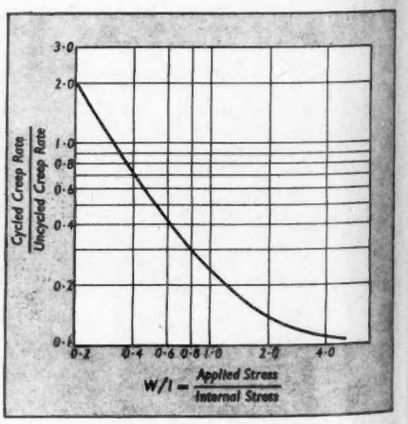


Fig. 1 Creep acceleration due to internal stresses caused by thermal cycling.

Research Report

on the work of

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density of sintered material and S is the specific surface in sq. cm. per cu. cm.

Much of the work on UO_2 has been concerned with the determination of *a* values in this way. The surface area values of interest lie in the range 15,000 to 100 sq. cm. per cu. cm., and have been measured in a modified BET apparatus using krypton as the adsorbate. The apparatus has been designed without stopcocks and with the minimum of dead space to give as great an accuracy as possible. It is considered that the results are accurate to within ± 5 per cent at the higher and ± 10 per cent at the lower values. *a* values have been determined on sintered material prepared from powders produced by the decomposition of ammonium diuranate and ammonium nitrate and by the oxidation of uranium metal. The effect of sintering route, e.g. low temperature non-stoichiometric sintering followed by reduction and high temperature stoichiometric sintering, has also been examined.

In addition to the surface area determinations the integral fabrication of UO_2-stainless steel fuel rods is being studied. In the present AGR (Advanced Gas-Cooled Reactor) fuel element, uranium oxide pellets are ground to fine tolerances and fitted into closely sized tubes. This process would be obviated if uranium oxide were swaged to high densities in metal tubes. Both hot and cold swaging of uranium oxide in stainless steel tubes is being investigated. Starting with a packing density of 8 gm per ml a maximum density of approximately 10 gm per ml has been obtained on cold swaging to a 30 per cent reduction in area. Hot swaging has shown little increase in density and a marked increase in damage to the metal sheath.

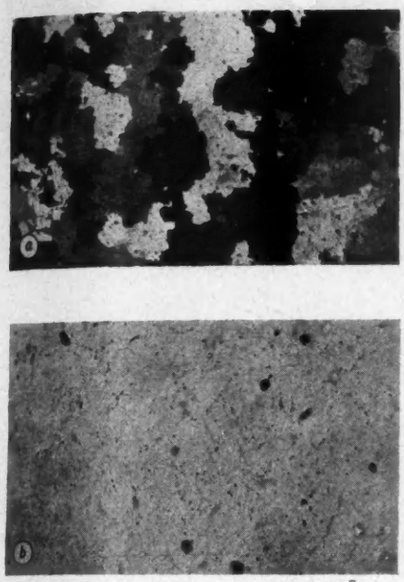


Fig. 2 Microstructures of heat treated unalloyed uranium:
(a) Polarised light, × 100.
(b) Normal illumination, × 230.

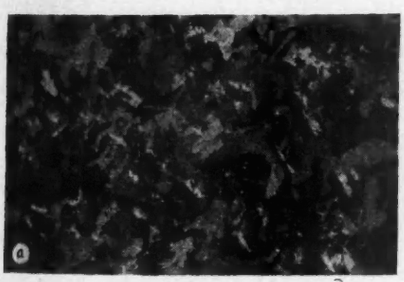


Fig. 3 Microstructures of cast uranium 1·5 w/o molybdenum alloy:
(a) Polarised light, × 100.
(b) Normal illumination, × 230.

Uranium Carbide

Uranium carbide also has advantages as a nuclear fuel. The maximum central temperature is again determined by the release of fission gases and is probably of the same order as that for UO_2. The thermal conductivity is however. much greater (4 to 6 times) so that the maximum permissible heat rating is correspondingly increased. The difficulty of fabricating UC to high densities and its high rate of reaction in oxidising media have till now kept it from finding favour as a nuclear fuel in gas and water cooled systems. Previous work on the oxidation rate of UC was however done using material of comparatively low density (80 per cent of theoretical) and work at NRC on fully dense UC has shown that at 550° C the oxidation rate of CO_2 is approximately the same as for uranium whereas at 800° C is it considerably less.

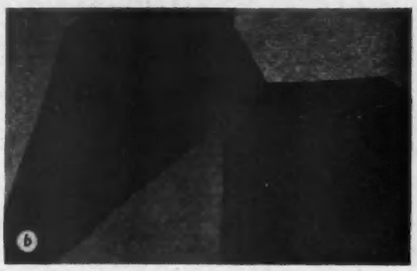
Fabrication routes are also being studied. Until now it has not been found possible to cold press and sinter either UC powder or mixtures of uranium and carbon powders to high densities ($>$ 90 per cent theoretical) even at very high sintering temperatures ($\sim$1,800° C). There are indications however that the presence of a liquid phase at the sintering temperature aids densification and work is proceeding to investigate this aspect.

Uranium carbide (melting point 2,450° C), unlike UO_2, is not volatile at its melting point and can be successfully arc melted. In this method mixtures of uranium metal and carbon are melted in a tilting water cooled hearth and poured into a preheated graphite mould. Castings, 0·3 in diameter and up to 1½ in long, for irradiation experiments in the Dounreay Materials Testing Reactor, are being produced with less than 2 per cent porosity and with the carbon content controlled with $\pm 0{\cdot}1$ w/o. Microstructures of cast carbide are shown in Fig. 4.

Cermets

Ceramic materials are brittle and are usually easily fractured when subjected to a thermal gradient as in a fuel element. One way of making a mechanically robust element and gaining some of the advantages of ceramics without their disadvantages is to incorporate the ceramic particles in a metallic matrix. By so doing the effective thermal conductivity is raised, the bonding of fuel to can is facilitated and, if a can fails, the damage is localised.

In a thermal reactor the addition of a metal to uranium oxide necessitates further enrichment so that for economic reasons only small amounts are permissible. In a fast reactor the effective density of the fissile component of the fuel must be high to achieve criticality and only cermets with an oxide content above about 50 w/o are of interest. A further requirement of cermets is that, to decrease damage to the metal by fission fragments, the dispersed ceramic fuel must not be below a certain minimum size (approximately 100 microns). The aim of the cermet work at NRC has been to produce high density cermets suitable for fast reactor application containing less than 50 w/o metal, with the



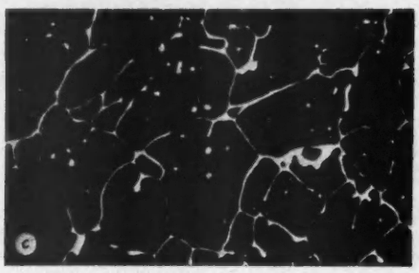


Fig. 4 Microstructures of arc-melted uranium carbide, × 120:
(a) 5·1 w/o carbon, showing UC_2 plates.
(b) 4·8 w/o carbon, the stoichiometric structure.
(c) 4·5 w/o carbon, showing uranium at grain boundaries.

uranium oxide of particle size 100 to 250 microns and with the metal preferably as a continuous matrix.

The technique of cold pressing and sintering uranium oxide or stainless steel cermets results in material of near theoretical density only if the oxide content is less than about 30 w/o. At higher oxide contents cermets prepared in this way have up to 20 per cent porosity. At these higher oxide contents, cermets of 98 per cent of theoretical density can be produced by hot pressing in graphite dies at 1,100° C and 6,000 lb per sq. in. A micrograph of a 60/40 w/o UO_2-stainless steel cermet is shown in Fig. 5.

In the Table some of the more important properties of the various fuels are summarised.

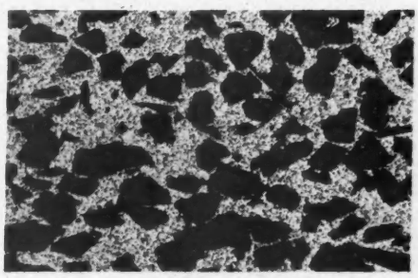


Fig. 5 Microsection of a 40 w/o stainless steel, 60 w/o UO_2 cermet, × 30.

USA Ford Gas-Turbine Shows Promise

It appears that Ford of America are well on the way to producing a gas-turbine which can compete with reciprocating engines for trucks, in both fuel economy and overhaul life.

FOLLOWING several years of research in turbo components and the building and developing of two models of simple-cycle, regenerative, gas turbines, Ford of America research engineers concluded that a significant advance in the state of the art would be necessary if a gas turbine were ever to be completely competitive with the reciprocating engine.

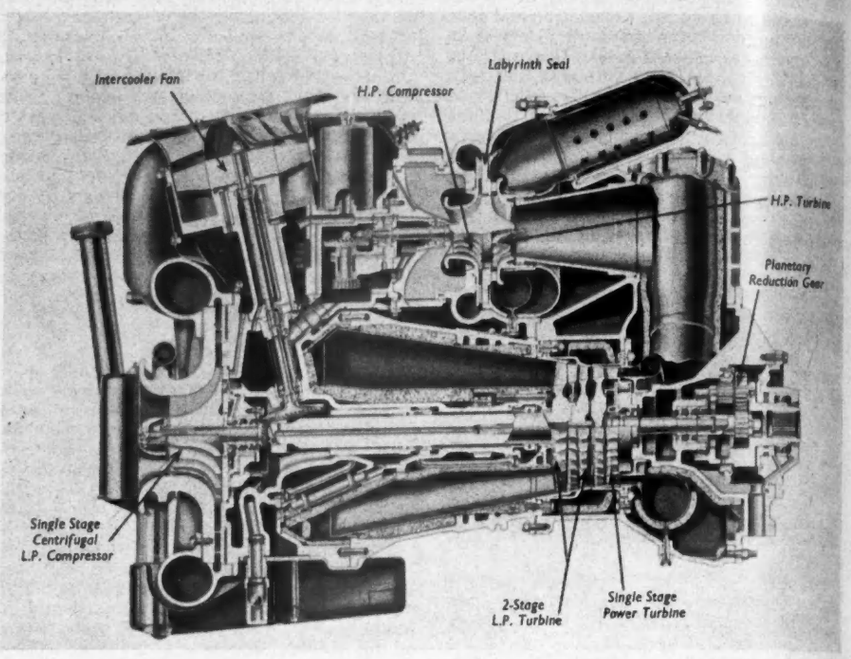
It appeared that a gas turbine of more complex cycle offered the best potential for a competitor. Brief mention of Ford's interpretation for such a turbine was made in ENGINEERING, vol. 187, 1959, p. 727, but fuller details have now become available through a paper recently presented to the Society of Automotive Engineers in America.

The cycle for the Ford 704 engine with a 300 hp rating may be described as a turbocharged gas turbine. It consists of two stages of compression, resulting in an overall pressure ratio of 16 : 1, with air-to-air intercooling between stages to reduce the work, size, and tip speed of the high-pressure compressor. A plate type recuperator is used between the HP compressor outlet and the primary combustor of the HP turbine. Reheat combustion is utilised between the HP turbine exit and the power turbine.

A unique feature of the cycle is the location of the power turbine between the HP spool turbine and the supercharging or LP spool turbines. Installation of the power turbine at this point in the cycle provides a very desirable speed relationship between the LP and HP compressors. This results in an extremely good part load fuel economy—according to the graph maximum fuel economy is at about 50 per cent full load. Near optimum load control is attained by varying the air flow, while turbine inlet temperatures are held almost constant.

While it was apparent that the end use of the turbine would be in truck applications, packaging for a passenger car challenged the ability of the design team to compress the arrangement of the components to the utmost.

While light weight is a desirable feature in an automotive gas-turbine, the manufacturing cost must obviously temper the designer's approach. A large part of the cost can be accounted for by the sheet metal assemblies fabricated from the more exotic stainless-steel alloys. These materials usually require careful processing during manufacture. The automobile industry is quite famous for its casting techniques, and the approach taken in the Ford 704 engine was to make use of castings wherever possible.



Large use is made of castings in the 704 engine which is now being road tested in a Ford truck.

The LP spool is essentially the turbocharger of the engine. It is an integral unit consisting of a two-stage turbine driving a single-stage centrifugal compressor at a design speed of 46,500 rpm. The bearing design is a two-bearing arrangement with a mid-shaft bumper bearing. In accordance with the concept of using castings, the LP spool consists of only one sheet metal component, which is the exhaust diffuser from the turbine wheel. The other components on this spool are either aluminium or nodular iron castings; or, in the case of the turbine shroud rings, fabricated from stainless-steel forged rings. The two turbine wheel stages are, however, precision investment castings of Inco 713 alloy.

The intercoolers are located between the scroll outlets of the LP spool and the interconnecting duct to the HP compressor inlet. The fan is an axial design with a sheet metal prewhirl vane which turns at 18,200 rpm.

The HP spool is a completely self-contained gas turbine unit. All accessories, oil pumps, fuel control, starter generator (the engine is started by cranking the HP spool) and so on, are driven from the accessory gearbox of this section of the engine. It can be seen that the rotating component is a back-to-back configuration. The radial inflow turbine is an integral part of the compressor wheel, with a labyrinth seal on the nozzle diaphragm between the compressor and turbine halves. An integral turbine-compressor design was necessitated by the combination of stress and temperature in the turbine wheel. Aerodynamic details of the cycle result in a 4 lb per sq. in differential pressure across the seal, which minimises the leakage from the compressor half to the turbine half. At design speed, the unit rotates at 91,500 rpm. This unit is a one-piece investment casting with a shaft flash-butt welded at the hub of the compressor inducer. Due to the unequal pressure ratios of the turbine and compressor, the thrust bearing must absorb 300 lb axial load.

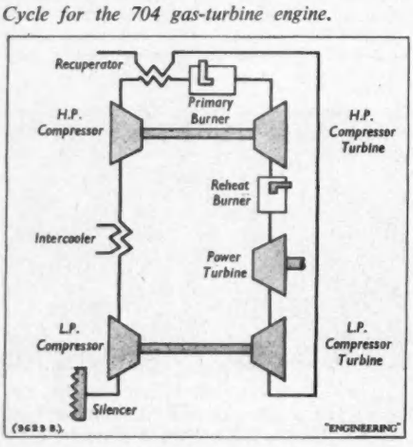
The power turbine is a single-stage unit which rotates at 37,500 rpm. The output shaft is reduced to 4,600 rpm by a planetary system using the reaction of the planet pinions against a fixed ring gear to drive the planet carrier and output shaft. The planet pinion gears, which at design conditions rotate at a spindle speed of 20,055 rpm use pressed-in copper lead bushings running on a nitralloy shaft.

"Z" flow configuration (cross counter flow) is used in the recuperator matrix. The engine uses two units which are 27 in long in the no-flow length, and approximately 4½ in long in flow length. The matrix is fabricated by stacking air cells and gas-side corrugations and furnace brazing the assembly.

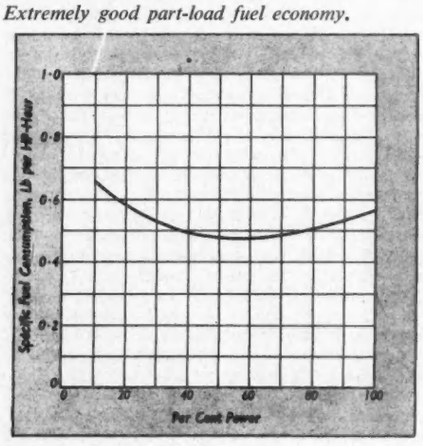
Mechanical design and development of an engine of this type and particularly in this size, has always appeared a formidable problem for the turbine designer. In the mechanical development of the Ford 704 engine many of the anticipated problems failed to materialise. In general, the mechanical development was not particularly difficult, probably because of the extensive rig testing of the components prior to engine testing.

Very little trouble was encountered in the initial operation of the power turbine and reduction gearbox. In fact, after an initial green run of 40 minutes, at the second build,

Cycle for the 704 gas-turbine engine.



Extremely good part-load fuel economy.



the power turbine and reduction gear were operated for 60 hours at design turbine inlet temperature, speed and load. Serious problems were, however, encountered when attempts were made to run at very low speeds and full turbine torque. Under these conditions, failure of the planet pinion bearings occurred through operation of the bearing in the boundary lubrication range. After several modifications of the engine hardware had failed to solve this problem, an extensive bearing analysis was made in which the characteristics of sleeve bearings for various clearance ratios, lubricant viscosities and speeds were programmed on a digital computer. A back-to-back gearbox test rig was fabricated, and the computer results correlated with test data to determine the boundary lubrication range in which hydrodynamic oil film could be broken and a failure of the bearing occur. From this data, a bearing design was evolved which would meet all the operating requirements of the engine.

An unusual turbine configuration has been designed into the 704 engine in that the power turbine and the LP spool turbines rotate in opposite directions without the use of an interstage nozzle vane. This arrangement was chosen to obtain improved acceleration of the LP during transient operation of the engine.

When accelerating from standstill while the power turbine is turning at low speeds, increased energy transfer takes place, and additional torque is applied to the LP spool turbine wheel, thereby improving the acceleration of this spool with a resulting increase in the power level of the engine. The effect is aerodynamically similar to that of variable geometry between the turbines.

Although to date the engine has not been tested in a vehicle, dynamometer operation has indicated that a significant gain in overall engine acceleration has been achieved with the contra-rotating turbine design. Since the transient analysis of a turbine of this type is an extremely complex problem, the magnitude of the advantage of transient speed characteristics could not be computed accurately, but dynamometer test data indicates that it may be substantial.

Fuel control system for the 704 engine can be considered as divided into two parts, each controlling a burner. Both systems are fed from a common, positive-displacement fuel pump. Basically, the primary control system maintains a fuel pressure at the HP turbine combustor fuel nozzle which is a function of the throttle angle, with a positive bias of HP spool speed. Mechanical overspeed of the HP spool is controlled by an overspeed governor. The governor, in effect, reduces the throttle angle, thereby reducing the fuel delivered to the HP turbine combustor.

Fords have installed the 704 engine in a tilt-cab truck and only moderate changes of the basic vehicle structure were required. After test stand operation for approximately one year, it will be interesting to know of the makers' experience and performance data on the operation of this engine in a vehicle. It appears that the original design target of an engine to compete with heavy truck engines, both from a fuel economy and overhaul life standpoint, can be attained. With the significant advantages of lightweight and low volume combined with the gas-turbine's torque characteristics, a very attractive power plant appears feasible.

Turbines and Boilers for 2,000 MW Power Station

The Central Electricity Generating Board's advanced approach to power station planning is borne out in the contract that has just been placed for the world's first 2,000 MW station at West Barton, Nottinghamshire. It is a typical example of the Board's policy of planning a complete power station for commissioning in a relatively short time.

The English Electric Company Limited have been awarded the contract for the four 500 MW single-line turbo-alternator sets. The first unit will be commissioned in 1965 and all four should be operational by the end of 1967. The units will continue the downward trend in capital and generation costs.

Each 500 MW unit comprises a multi-cylinder 3,000 rpm reheat turbine with multiple exhausts arranged as a tandem compound unit coupled to a hydrogen/water cooled alternator of the direct cooled type. Solid couplings are employed between rotors, and each shaft is mounted on two main bearings so that the assembly and maintenance of the machine are kept as simple as possible. Automatic shaft gland packing is incorporated.

As in all these large machines, electronic supervisory gear with centralised control will be used for simplified and reliable operation.

The turbine operates with steam at 2,300 lb per sq. in gauge, 1,050° F at the turbine stop valve with reheated steam to the intermediate pressure cylinder at 1,050° F. The vacuum at maximum and continuous rating is 28·7 in Hg.

To meet the specified high pressure and temperature requirements, the HP cylinder employs a double casing arrangement over the first stages with the expanded steam passing over the outside of the inner casing and through the remaining stages.

Maximum continuous rating for the direct-cooled alternator is 500 MW. The machine runs at 3,000 rpm and generates at 22 kV. It is designed for a short circuit ratio of 0·4 and a power factor of 0·85 lagging. Two fluids are used in the direct cooling circuits, hydrogen at 60 lb per sq. in for the hollow rotor conductors and for the stator core, and water for the hollow stator conductors. The hydrogen is circulated by a multi-stage axial blower mounted on the rotor shaft. The recooled gas enters the conductors at each end of the rotor body to cool the slot and end windings separately.

Excitation current for the 500 MW alternator is provided by a direct coupled exciter alternator, the output of which is rectified by a bank of silicon rectifiers feeding directly into the slip rings of the main alternator rotor. Control of the excitation is obtained by a continuously acting automatic voltage regulator, which adjusts the rotor current of the exciter alternator. This current is derived through rectifiers from a high frequency alternator which is coupled to the exciter.

For large unit ratings, this system offers important advantages over conventional dc exciters; the large speed-reducing gearbox is not needed and the maintenance problems of heavy-current commutators and their associated brushgear are eliminated.

A feature of the condensing plant which is also being supplied by English Electric is the use of double tube-plates thereby preventing or at least reducing to a minimum the risk of contamination of the feed water by a cooling water leak at the tube plate.

The four 500 MW reheat boiler units are being supplied by International Combustion Limited, 19 Woburn Place, London, WC1. The units, which are of the controlled circulation type, will be skin cased and arranged for cubic expansion down to the economiser outlet. Each unit is arranged as a single subdivided furnace employing tangential firing of the fuel from six mill units of the pressure type. Steam pressure for the units is 2,400 lb per sq. in and the primary steam evaporation is at the rate of 3,450,000 lb per hour.

Flexible Gear-Coupling Takes Severe Misalignment

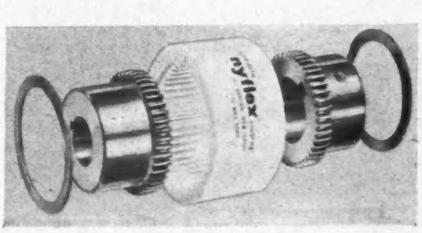
Eight hundred hours of continuous running at almost 5° total misalignment has been recorded for one of a range of flexible gear-couplings now available for the first time in the UK.

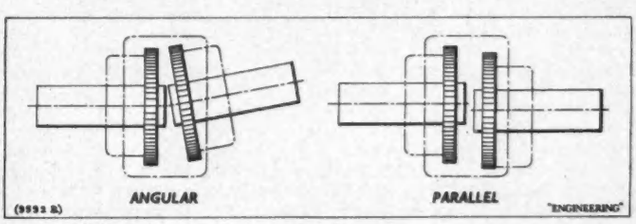
From the top illustration, the five-part construction of the coupling can be seen. The steel hubs are crown hobbed to allow for additional misalignment and prevent gouging of the nylon sleeve. The makers—Sier-Bath Gear and Pump Company Inc., of New Jersey, USA—claim that if the coupling can be physically installed and the sleeve engaged with the hubs, it can be safely run for a long period. The unit will absorb both angular and parallel misalignment (see drawing) and end float with minimum backlash.

The couplings—which are known as Nyflex—weigh only 3½ lb and the nylon sleeve has almost frictionless properties thus eliminating the need for lubrication. When a coupling was being tested, there was no sign of wear even though dirt, oil and water were thrown into it. Two spring-steel alloy retaining rings hold the sleeve on the hub and although they can be quickly removed, they can withstand an end thrust of 5,000 lb.

A wide range of shaft speeds and horsepower capacities is offered. Standard designs range up to 5,000 rpm with higher ratings possible on consultation with the company. At 5,000 rpm 42 hp can be developed giving a torque of 530 lb-in. Ten standard bores from $\frac{7}{16}$ in to $1\frac{3}{8}$ in are available, with push fits up to $1\frac{1}{4}$ in and press fits up to $1\frac{3}{8}$ in.

In the UK, Nyflex couplings are obtainable through the sole agents, James Day (Machinery) Limited, 28 Maddox Street, London, W1. The couplings are said to be smaller than any other in the same operating range and about half the price of a comparable all metal lubricated one. The complete line of standard and special type Sier-Bath flexible gear couplings is available from the same source.





The drawing alongside shows the degree of angular and parallel misalignment that can be tolerated in the running of the Nyflex coupling.

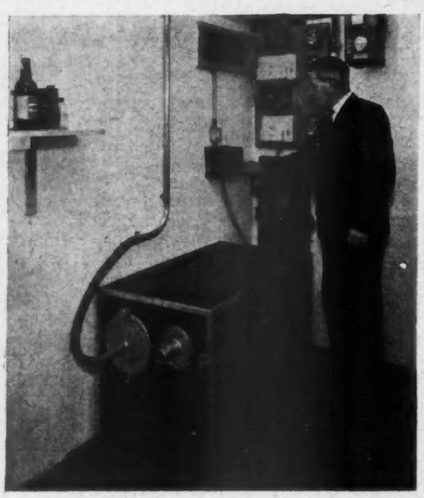
Central Cleaning

CENTRAL cleaning offers many of the same advantages as central heating—simplicity, convenience, and ease of operation. Like it, it is best incorporated when the house is being built but it is possible to add it later without too much upheaval of the structure.

The idea is not a very new one, but recent developments have made it more generally available—and more efficient. Sir George Godfrey and Partners Limited, of Hampton Road West, Hanworth, Middlesex, are supplying equipment for some houses now being built and are also showing the system installed in one of the houses at the Ideal Home Exhibition at Olympia, London, which is open from 7 March to 3 April. The unit is called the Dustmaster and the illustrations show part of the prototype installation.

Basically, the idea is to have a system of pipes extending round the house under the floors, all radiating from a central suction unit in the basement or garage. Outlets to the pipes are fitted in each room—if necessary two in a very large or awkwardly shaped room—into which a flexible hose is plugged. On the free end of the hose is a conventional vacuum cleaning tool, changeable to suit the requirements.

Advantages are that it is not necessary to carry a comparatively heavy suction unit around the



house, and there is no trailing electric flex to get caught up or otherwise cause trouble. Moreover the static nature of the suction unit enables it to be made heavier, larger and generally more efficient than the portable type which of necessity must be kept small and light enough for a woman to carry, with the attendant risk of its performance being restricted. A single large central unit can produce a high vacuum and give very good cleaning powers; the only item to be moved from room to room is the light flexible hose and the connecting standpipe that fits in the system socket.

The suction unit shown in the illustration is installed in a garage and is somewhat larger than needed for most houses. A typical enclosure for a house unit would be 32 in long by 20 in deep and 15¼ in wide. There is a wide choice of sizes from the standard range of machines made by the firm so that large or small houses, hospitals, schools and factories can be catered for. The pipes running through the house, which are normally laid between the joists, are 1¼ in outside diameter and can be of light alloy with plastic junction sleeves, or of plastic throughout. With the light alloy no special jointing is needed as the suction tightens the sleeves on the pipes and forms an effective seal.

The outlets are closed by a spring loaded flap valve resting on a rubber seat. The hinge of the valve is left comparatively loose so that the seating is self centring. Again the action of applying a vacuum improves the closure and very little loss has been experienced in practice. The standpipe, which is made of aluminium, has a lip that engages with the flap of the outlet, causing it to go over centre and seal the pipe in position. It is removed by a twist in the opposite direction. The flexible hose as normally supplied gives a coverage over a radius of 17½ ft from the stand pipe, enough to reach most points in a room. The positioning of the outlet in the room requires some consideration so that the most effective

A centralised vacuum system removes the labour of carrying a suction unit round the house, leaving only a flexible hose to be handled. The standpipe is plugged into a self sealing socket and the hose gives a working radius of 17 ft 6 in.

use of the apparatus can be obtained. The cleaning of staircases, usually an awkward job with a portable unit, is simplified with the Dustmaster.

The actual cleaning operation follows the normal pattern but afterwards the only items to be stowed away are the flexible hose and the tools, taking up very little room. The dust is collected in a bag in the central unit, removal for emptying being a simple affair. A standard domestic plant is rated at 1½ kW and will extract air at 50 cu. ft per minute, producing a vacuum of 7 in of mercury. For larger establishments larger units are available. One big advantage particularly for hospitals is that at the cleaning point itself there is little or no noise and the patients' rest is not disturbed.

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